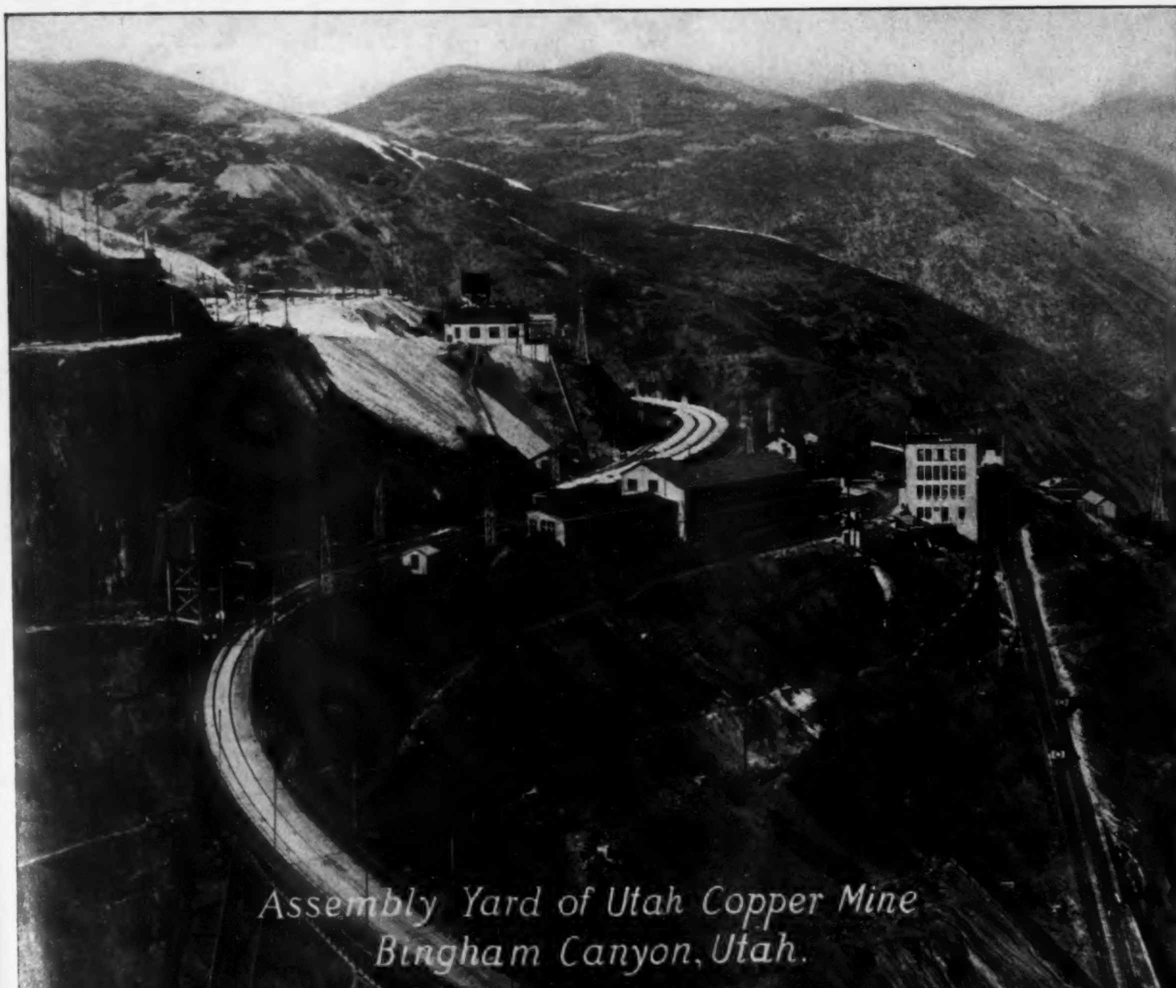
IN TWO SECTIONS—SECTION ONE

MECHANICAL ENGINEERING



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P. R. Love

W. E. Wickenden

W. R. Whitney

F. B. Jewett

F. N. Speller

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John Hays Hammond, consulting mining engineer, received his Ph.B. from Sheffield Scientific School, Yale University, in 1876, after which he took a mining course at the Royal School of Mines, Freiburg, Saxony. He received his D.E. from Stevens Institute of Technology in 1906, and the degree of LL.D. from St. John's College in 1907 and Yale in 1925. He has examined properties in all parts of the world and has been associated with many of the important financial groups of this country, promoting several of the largest and most valuable mining properties in the United States and Mexico. He has also been active in interests outside of mining, including hydroelectric enterprises, irrigation projects, etc. He has lectured at Columbia, Harvard, Yale, and Johns Hopkins.

W. R. Whitney, director of the Research Laboratory of the General Electric Co., Schenectady, N. Y., since 1900, was graduated from Massachusetts Institute of Technology in 1890. In 1896 he received his Ph.D. from the University of Leipzig, in 1919 an honorary Sc.D. from Union University and a Ch.D. from the University of Pittsburgh, and a Sc.D. from the University of Syracuse in 1926 and from the University of Michigan in 1927. He has served for many years on the faculty of M.I.T., since 1908 in the capacity of non-resident professor of theoretical chemistry. He is a member of the M.I.T. Corporation, the U. S. Naval Consulting Board, the advisory committee of the United States Bureau of Standards, and of the National Research Council. He is a past-president of the American Chemical Society, and of the American Electrochemical Society.

F. B. Jewett is president of the Bell Telephone Laboratories, Inc., and vice-president of the American Telephone & Telegraph Co., in charge of development and research. He was graduated from Throop Polytechnic Institute in 1898, and received his Ph.D. from the University of Chicago in 1902; D.Sc. in 1925 from New York University, Dartmouth College and Columbia University, and in 1927 from the University of Wisconsin. At the start of his career Dr. Jewett served as a research assistant at the University of Chicago and then as an instructor at Massachusetts Institute of Technology. He became connected with the American Telephone & Telegraph Co. in 1904, holding successively the positions of transmission engineer, assistant chief engineer, and chief engineer. In 1922 he became a vice-president of the Western Electric Co.

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W. E. Wickenden, director of investigation for the Society for the Promotion of Engineering Education, received the degree of B.S. from Denison University and then for several years served as instructor in the University of Wisconsin. From 1909 to 1914 Mr. Wickenden was associated with Massachusetts Institute of Technology as assistant professor of electrical engineering, resigning to become personnel manager of the Western Electric Co. He served for two years as assistant vice-president with the American Telephone & Telegraph Co. before accepting his present position. In the fall of this year Mr. Wickenden is to become president of the Case School of Applied Science.

This Month's Cover is used in connection with the leading article by Mr. Goodrich on "Ore Handling at the Utah Copper Company's Mine and Mills," and shows the assembly yard of the mine in Bingham Canyon.

② MECHANICAL ENGINEERING

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Ore Handling at the Utah Copper Company's Mine and Mills

Drilling and Blasting, Loading With Shovels, and Hauling Ore at the Mine—Transportation of Ore From Mine to Mills—Handling of Ore at the Mills

By H. C. GOODRICH,[1] SALT LAKE CITY, UTAH

THIS paper will describe the methods used in handling overburden and ore, and will treat the subject in logical order as follows:

1 Operations at the mine at Bingham Canyon
  - *a* Drilling and blasting
  - *b* Loading by shovels
  - *c* Transportation

2 Transportation of the ore from the mine over the main-line railroad to the mills at Magna and Arthur

3 Handling of the ore at the mills.

Operations at the Mine

Fig. 1 is an airplane view of the operations at the mine and shows the open pit in the bottom of Bingham Canyon with its numerous terraces extending up the side of the mountain a vertical distance of 1700 ft., railroad tracks leading from these terraces to the various gulches where the overburden from the mine has been dumped, and also tracks leading from these terraces down to near the bottom of the canyon where the assembly yards are situated. This view also shows the mine waste which has been dumped in nearby and distant gulches.

An idea of the magnitude of the operations at this mine can be had from the view from the county road, where the sight of the many shovels loading ore and of trains of ore and waste being hauled by electric and steam locomotives gives the impression, which is a true one, that here there is more mechanical energy being used than can be seen from any other one place in the country.

When reporting on the Utah Copper property thirty years ago, Daniel C. Jackling stated that the overburden would be loaded into railroad cars by steam shovels and moved to and deposited in the nearby gulches, and the ore when uncovered would be loaded into railroad cars and sent to the mills for concentration. That vision has now been realized as about 190,000,000 tons of overburden have been moved to date, substantially all of which has been deposited in the gulches in Bingham Canyon, and 176,000,000 tons of ore have been loaded and shipped to the mills.

The site of the Utah Copper mine, Fig. 2, before open-pit mining was begun was an ordinary-appearing mountain, having nothing peculiar in its appearance to differentiate it from the other mountains. This mountain lies between the main Bingham Canyon and the Carr Fork branch of the main canyon. The site of the mine covers some 723 acres, and present workings, Fig. 3, of the Utah Copper mining property now include both the Boston Consolidated property and the original Utah Copper holdings. The first steam shovels were used on what is now the Utah Copper property in 1905. The Boston Consolidated began its operations by using narrow-gage equipment, but the Utah Copper Company at the outset adopted standard-gage.

In 1910, when the consolidation of the two properties was made, a comprehensive plan of development for future operations was decided upon, which included the fixing of the elevations for the various main levels and the adoption of railroads for transporting the overburden and ore. The railroad switchback tracks were located both up the main canyon and also up Carr Fork on maximum 4 per cent grades equated for curvature and connecting with each of the levels, thus giving two independent entrances to the mine.

These tracks were located with a maximum of 16-deg. curves, using 65-lb. rail laid on 7-in. × 8-in. × 8-ft. Oregon fir ties, and tie plates and rail braces where necessary, the switch turnouts being laid with No. 7 frogs.

As the ore was uncovered on the different levels and the tonnage of ore going over the tracks increased, the 65-lb. rail first used was replaced by 90-lb., and the 65-lb. rail thus released was used on the shovel levels and dump tracks.

At the beginning, 6-cubic yard dump cars were used for handling the overburden, and later, cars of 12-cubic yard capacity; but when the large-capacity dump car was developed in 1916, eleven years after the first removal of overburden by shovels, 30-cubic yard cars were adopted, the Utah Copper Company being the first to use dump cars of so large a capacity. This necessitated larger haulage units, and the four-wheel steam locomotives, which had a tractive effort of 19,300 lb., were replaced with six-wheel steam locomotives having a tractive effort of 30,500 lb.

The old-style steam shovels mounted on railroad trucks have been replaced by shovels operated with electric power and mounted on caterpillars, and the size of the dippers increased from $3^1/_2$ to $4^1/_2$ cu. yd. The steam locomotives are likewise now being rapidly replaced by electric locomotives. The equipment being used at the mine is the last step in the program of enlarging and modernizing in the interests of safety, efficiency, and economy. No further changes will be made until advances in the art develop machines of superior qualities sufficient to warrant them, or until the adoption of a partial change in mining procedure necessitates other types of equipment.

[1] Chief Engineer, Utah Copper Company.

For presentation at the Semi-Annual Meeting, Salt Lake City, Utah, July 1 to 4, 1929, of The American Society of Mechanical Engineers. All papers are subject to revision.

Note: Statements and opinions advanced in papers are to be understood as individual expressions of their authors, and not those of the Society.

Drilling and Blasting

The first step is drilling the material. Three compressors, driven by synchronous motors, furnish 11,200 cu. ft. of free air per minute, about 90 per cent of which is used for drilling. This compressed air is supplied to the drills at 75 to 80 lb. pressure through a continuous air line going entirely around the workings, and delivered to each level through headers. Both the ore and the waste break readily, and the plan of attack is therefore about the simplest that could be devised, namely, blasting all material from a row of holes drilled at about a 10-deg. downward inclination from the horizontal into the toe of the bank. In general this method is the one which has been in use at the mine for a great many years.

Fig. 1 Airplane View of Operations of Utah Copper Mine, Showing Open Pit in Bottom of Bingham Canyon With Its Numerous Terraces, Gulches Where Waste Is Dumped, Etc.

When stripping was first started, air drills mounted on tripods were used, with ordinary dynamite for the explosive. Later black powder was added to give more of a heaving effect to the charge. At present an ammonium nitrate powder of low freezing character with a rating of 60 per cent dynamite is the only powder used for the main blast. Reciprocating $3^1/_2$-in. piston drills (Fig. 4) are used. A hole is started with a $3^3/_4$-in. cross-bit, which is reduced to $2^1/_4$ in. for the last bit. The holes are spaced 15 to 20 ft. apart and are about 23 ft. in depth. A drill crew consists of a machine man and two helpers. These crews also do the blasting and trim the banks (Fig. 5), there being two crews to each shovel. The drilling and blasting follow behind the shovels as they move across the benches, and generally do not approach nearer to the shovel than 200 ft. An average of 45 ft. is drilled per drill shift, while 0.022 ft. of hole and $^1/_8$ lb. of explosive are used per ton of material broken. The position of the holes is selected by the powder foreman, who has been in charge of this work since the beginning.

After being drilled the holes are chambered at their bottoms for the main charge. On an average it is necessary to chamber the holes in 4 shots, using approximately 7, 15, 30, and 50 sticks of powder, respectively. After the hole is chambered the main charge of powder, which varies between 150 and 250 lb., is placed therein through a $1^1/_2$-in. pipe and tamped in place and later exploded by means of a detonator consisting of a stick of powder having attached to it a No. 6 cap and 6 ft. of fuse. On an average, 7 holes are fired as one round. It is occasionally necessary to drill holes from the top of the talus as well as from the top edge of the bench for the purpose of blasting off projections of rock which did not break from the toe-hole blasts, and the few boulders which cannot be handled by the shovel dippers are blockholed by jackhammer drills and blasted.

Sixteen per cent of the powder is used for chambering, 69 per cent for main blasts, and 15 per cent for secondary blasting. Generally the blasting is done while the shovels are not operating, such as at the lunch hour or at the end of the shift, and ample warning is given of the intention to blast by blowing whistles and the air siren in the lower yard.

Loading With Shovels

The general plan for loading ore at the mine is to work full capacity during the daylight shift. At the end of the day's work, when the amount of ore loaded during that shift has been computed, enough shovels are detailed for loading ore on the night shift to make up the quantity required. To load 110,000 tons of ore and overburden in 24 hours requires about 30 shovel shifts every 24 hours, and as there are 23 shovels this means that from 7 to 10 shovels would be required to work during the night.

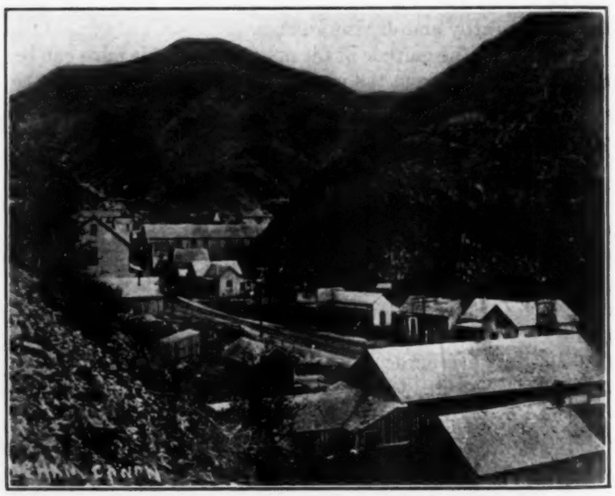


Fig. 2 Site of Utah Copper Mine Before Open-Pit Mining Was Begun

The night shift is also utilized for maintaining good working conditions at the waste dumps. When one of the dumps in a series is lagging behind the others, stripping is removed on that mine level at night. The general plan of working the equipment to its fullest capacity during the day shift is also the safest.

As previously stated, the loading of ore (Fig. 6) and overburden (Fig. 7) is done with electric shovels, the clean, smooth operation of which as compared with that of the steam shovel is apparent to every one at the mine, and gratifying to those immediately concerned with their operation. The steam shovel requires coal and water, both difficult and expensive to supply, particularly during winter months. The electric shovels will load as high as 4800 tons of ore per shift, and in loading ore will handle about 250 tons more per shift than when loading overburden.

Electric power for the Utah Copper operations is furnished by the Utah Power & Light Company. This power is received at its terminal station located about ten miles east of Magna at 120,000 volts, and transformed to 44,000 volts at the Utah Copper Company's central station at Magna. Two 3-phase lines of No. 2 copper wire, 14 miles long, extend from Magna to Bingham, where at a central switch rack they split into a two-circuit line, and these two latter feed lines supply two outdoor substations, each of which contains for shovel operations six 400-kva. transformers, where the tension is reduced to 5500 volts. The power at 5500 volts is carried from each substation over two single-circuit lines, mounted on wood poles, which encircle the entire area of shovel operation. These lines are built close to the outlets of the different mine levels, and with this system of distribution it is possible to feed any level from any of the four secondary trunk lines. The reason for such flexibility in the secondary distribution system is to provide insurance against delays, as continuity of service is of the utmost importance.

The problem of getting power from the distribution lines to the shovels was a difficult one because of the danger of blasting the lines, and further because such power lines must be portable.

FIG. 3 SHOWING PRESENT WORKINGS OF UTAH COPPER MINE

FIG. 4 AIR DRILL AT WORK

Rubber-covered cable insulated for 7500 volts was tried, but was supplanted by light, portable steel towers mounted on skids. These towers are approximately 25 ft. high and 6 ft. square at the base. They carry three No. 2 stranded copper wires in spans up to 300 ft. Each shovel receives power from this portable line through a connecting 500-ft. length of four-conductor trail cable, three of these conductors being for power and the fourth for a ground. This cable is wound on a reel mounted on the rear of each shovel, and permits moving the shovel a distance of 400 ft. before the connection must be changed.

Eight of the twenty-three shovels use alternating current, and the other fifteen direct current. The alternating-current shovels have rheostatic control, and the direct current shovels use the Ward Leonard control.

The alternating-current equipment, located directly on the shovel, consists of the following:

One three-phase 300-kva. 5000/460-volt transformer, controlled through a suitable oil circuit breaker
Two 100-hp. 440-volt phase-wound induction motors, for operation of the hoist motion
One 60-hp. similar-type motor for the operation of the boom swing; one similar motor for the operation of the dipper crowd.
All of the these motors are controlled with electropneumatic contactors actuated by proper-sequence switches through drum controllers.

The direct-current equipment consists of the following:

One 225-kva. three-phase 60-cycle 5000-volt 1200-r.p.m. synchronous

motor, controlled with a 7500-volt solenoid-operated automatic circuit breaker, and direct-connected to a 125-kw. 250-volt differentially compound-wound direct-current hoist generator, a 30-kw. 250-volt differentially compound-wound direct-current swing generator, and a 29-kw. 250-volt differentially compound-wound direct-current crowd generator

Two 105-hp. 250-volt direct-current series-wound mill-type motors for hoist service

One 43-hp. 250-volt direct-current shunt-wound mill-type motor for swing motion

One 40-hp. 250-volt direct-current shunt-wound mill-type motor for crowd motion.

The control for these motors and generators consists of field resistors, with drum controllers for varying the field strength.

The booms on the shovels are 30 ft. in length and the dipper handles 21 ft., and the shovels can make a 21-ft. cut across the level. The boom swings through an arc of 190 deg., and a shovel can dump at a height of 17 ft. above grade. The shovels are mounted on caterpillar trucks having a maximum spread of 22 ft. 6 in. The use of caterpillars eliminates the necessity for maintaining a track under the shovel and the employment of jacks to steady the shovel when in operation. Because of the absence of anything like jacks to impede its motion, a shovel running on caterpillars can quickly advance or back away when necessary.

FIG. 5 TRIMMING A BANK

FIG. 6 LOADING ORE WITH ELECTRIC SHOVEL

Usually from ten to twelve 80-ton ore cars are brought in and spotted for loading, the locomotive remaining coupled. When the train is loaded and en route to the yard another locomotive will bring in the next train and the process of loading continues. The procedure is the same in loading waste. The average capacity of the electric shovels is about 600 tons per hour, and an ore train with a capacity of from 800 to 960 tons will keep the shovel occupied from $1^1/_4$ to $1^1/_2$ hours. Waste trains consist of from three to seven 30-yd. cars, depending on the proximity of the waste dumps. Each level has its separate outlet to waste dumps where the latter are adjacent to the work. One track to distant dumps, however, usually serves about three levels.

A shovel will start making its cut at one end of a bench and will proceed across the bench to the other end, loading the material whether it be ore or waste. When it reaches the end of its travel the operation is repeated. As the different shovels move across their respective benches their progress is arranged so that one shovel will not be directly above another. The table which follows gives the performance of the shovels for 1928.

PERFORMANCE OF SHOVELS IN 1928

Kind of electric power	Material	Shifts worked	Loaded: Tons	Loaded: Tons per shift
A.c.	Ore	929.87	3,613,720	3886
	Waste	1651.76	6,908,460	3692
	Total	2581.63	9,712,180	3762
D.c.	Ore	3244.74	12,942,350	3989
	Waste	2228.62	8,301,710	3725
	Total	5473.36	21,244,060	3881

This shows that both the a-c. and the d-c. shovels loaded more per shift in ore than in waste, the average of the two being about 7 per cent more. It also shows a slightly higher performance of the d-c. over the a-c. shovels. During the good-weather months the shovels load about $7^1/_2$ per cent more than the average for the year. In 1928, from May to October, inclusive, the a-c. shovels averaged 4031 tons per shift as against 3762 tons, the average for the year, while during the same months the d-c. daily average was 4097 tons as compared with a mean for the year of 3881.

FIG. 7 LOADING OVERBURDEN WITH ELECTRIC SHOVEL

The d-c. shovel will load 25 per cent more material than the a-c. shovel with the same power, as shown by the following data for 1928, when the cost for power was 30 per cent of the total cost of shovel operation.

	A-c. shovels	D-c. shovels	Totals
Kilowatt-hours	2,380,041	4,202,539	6,582,580
Tons loaded	9,712,180	21,244,060	30,956,240
Tons per kw-hr	4.081	5.055	4.703

During 1928 the shovels were actually loading 82.1 per cent of the total time they were on shift. The loss of time from electrical trouble is the smallest of all of the losses, and the greatest amount of time lost is that due to switching ore or waste cars. This is a loss of time which is inherent in the method and could be avoided only by having passing tracks extending the full length of the levels so that an empty train could be spotted immediately upon the leaving of the loaded train. It is, however, impracticable to have more than one track across a level.

Transportation

This item includes the hauling of empty ore cars to the shovel and the delivery of these cars, Fig. 8, loaded with ore, to the assembly yard, Fig. 9, and the same kind of operation in hauling overburden to the dumps where it is unloaded, Fig. 10.

When the electrification program now in progress is complete there will be forty 75-ton electric locomotives at the mine. These will operate principally from trolleys, of which each locomotive will have one spring-raised, air-lowered pantograph and two side-arm collectors which are swung out and withdrawn with air. They are of the articulated type, have 46-in. rolled steel wheels, and are equipped with four 250-hp. totally enclosed roller-bearing 750-volt series motors. The control is by a magnetic contactor with 21 points. The rating at 1040 amperes is 34,400 lb. tractive effort at 10 miles per hour with the line voltage at 675, and for continuous operation at 420 amperes is 8800 lb. tractive effort at 14.5 miles per hour. This is equivalent to hauling 12 empty ore cars, each weighing 21.5 tons, up the 4 per cent switchbacks at 10 miles per hour.

The side-arm trolleys are used when the locomotive is crossing

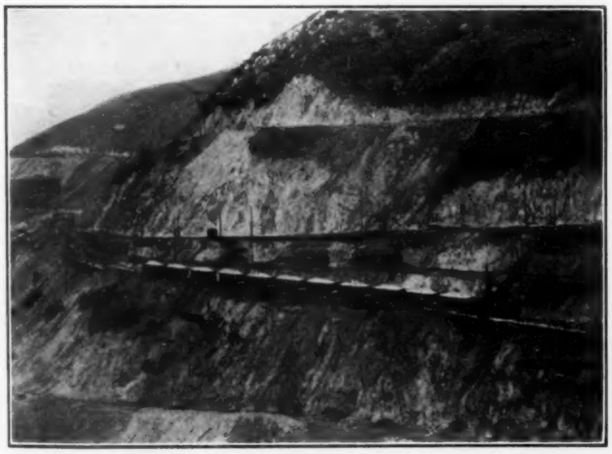


FIG. 8 ORE TRAIN ON A SWITCHBACK

a bench. For emergency uses there is a cable reel mounted on the locomotive. This reel is motor operated and holds 1000 ft. of No. 0 A.W.G. flexible cable.

Seven of the locomotives have storage batteries of 120 cells. They operate the locomotive at approximately one-third speed, and have a rating of 162 kw-hr. They are charged by a motor-generator set in the cab, the charging being fully automatic. They will deliver 300 volts at the rate of 75 kw. for a 20-min. period.

Power is obtained from the same substations used for supplying the shovels. The locomotive requirements call for four 1000-kw. converters in each substation, converting to 750 volts d.c. The locomotive power lines are on the same towers and poles as the shovel lines, and the system is built so that six locomotives, operating on three levels, can draw their power from two sources over two feeder lines. Standard catenary construction is used for the trolley lines over permanent tracks, and simple direct suspension elsewhere.

On a track layout such as that at the Utah Copper mine where there are many trains per day going over the switchbacks, there must be a simple and effective way of directing their movements. This is done by having flagmen stationed at points where they have a view of two switchbacks, and who control the movements

FIG. 9 ASSEMBLY YARD OF MINE. CARR FORK VIADUCT IN FOREGROUND

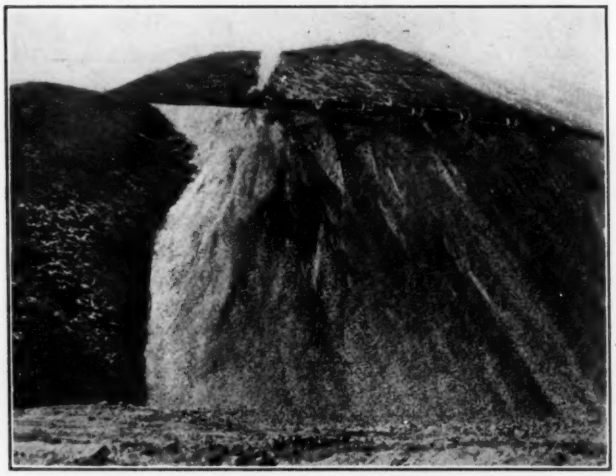


FIG. 10 DUMPING WASTE

of the train by flag and telephone. This system was started twenty-two years ago and is still being used with satisfactory results.

As an idea of the quantity of material which was loaded by power shovels and hauled from the mine, the following table is submitted:

Year	Tons
1906	229,320
1916	24,090,790
1926	31,091,540
1928	30,956,240

Transportation to the Mills

The next step is the delivery of the ore from the assembly yards to the mills at Magna and Arthur, and this movement keeps pace with the movement of the ore to the yards at the mine, thus avoiding congestion. The main line of the Bingham and Garfield Railway connecting the assembly yards with the mills at Magna and Arthur was constructed in 1910 and 1911, together

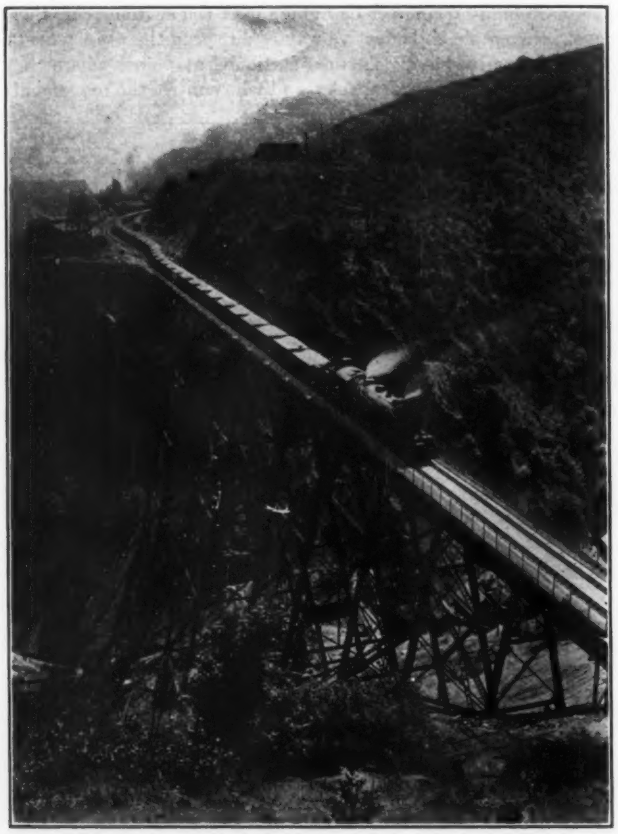


Fig. 11 Ore Train Leaving Assembly Yard and Crossing Markham Viaduct

with other tracks used in connection with the Utah Copper Company's operations and the common-carrier operations of the airway company. Additional trackage has been laid from time to time until the aggregate length of all tracks is as follows:

	Miles
Main line	20
Tracks at Arthur and Magna	41
Main-line sidings	6
Bingham yards	8
Bingham switchbacks	19
Bingham level, dump, and other tracks	57
Total	151

The 17-mile line from the assembly yards to the mills has a maximum grade of 2.5 per cent, and an average of 2.2 per cent in favor of the loads. Its upper two miles is on the steep mountain side of Bingham Canyon, where four tunnels, having a total length of more than a mile, and three steel viaducts, each approximately 700 ft. long and 200 ft. high, were constructed. Emerging from Bingham Canyon, the road passes along the foothills of the Oquirrh Range; the entire route is a tortuous one, 45 per cent of its length being on curves, most of which are 6 deg., and the maximum curve is 10 deg. 10 min. The track was originally laid with 90-lb. rail resting on 7-in. × 9-in. × 8-ft. ties, of which there were 18 and 20 to the 33-ft. rail on tangents and curves, respectively. These ties were laid on 12 in. of stone ballast. As this railroad is the "neck of the bottle," only the best of material and equipment was used, and it is maintained at all times in good operating condition.

Since the original construction, reballasting has given 9 in. of gravel under the ties in addition to the stone ballast, two additional ties to the 33-ft. rail have been added, the length of ties on curves has been increased to 9 ft., and the weight of the rail has been increased to 110 lb. per yd., and other track material has been increased in proportion. About 3.6 miles of the track has the so-called "mild manganese" rail, containing from 1.3 to 1.6 per cent of manganese. There are six passing tracks along the main line, spaced at approximately 2-mile intervals.

The movement of trains, while directed by dispatchers, is also controlled by automatic signals. These are placed at each end of the passing tracks and two intermediate between one passing track and another. They are of the A.P.B. (absolute-permissive-block) type; that is, they allow the train to proceed uninterrupted, to proceed with caution expecting to find the next block closed to its entry, or require it to stop. The signals also indicate if there are any broken rails, open switches, or anything in the track structure which would cause a derailment. They receive their power from a 440-volt line, which is transformed to 110 volts at each of the passing tracks, and this in turn is stepped down to 3 volts in the signal cases. Signals also control entrance to the main line at the junctions where the tracks to the Magna mills and the Arthur mills branch from the main line.

Below the Bingham yard the main line is further protected by a remote-controlled derail, opened and closed by the operator at

Fig. 12 Spotting Cars at Car Dumper, Magna

Bingham. This derail is normally open. Should a car in the Bingham yard get out of control it would be derailed before it entered the first tunnel out of Bingham, and no train can leave Bingham until the operator has closed the derail. The diverting switch at Arthur Junction is operated by remote control by the dispatcher at Magna, who thereby directs the course of the train either to the Arthur or the Magna mill. At the upper ends of the passing tracks the switches are of the spring type, with an oil shock absorber. When two trains meet, the idea is to permit both of them to proceed without having to stop. The upbound train takes the passing track and proceeds on its way through the spring switch without delay.

The trains operated on the Bingham and Garfield Railroad hauling ore from the Utah Copper mine ordinarily consist of a

Mallet locomotive and 50 cars. The ore cars, originally of the hopper-bottom type and holding 60 tons of ore, have been remodeled to the box type, having a capacity of 80 tons. They weigh empty 21.5 tons. These cars are of all-steel construction, 31 ft. in length over the coupler contact line, and 10 ft. high over all. They are supported on two four-wheel trucks having $6^1/_2$-in. × 10-in. journals and rolled steel wheels. In 1928, in hauling 217,259 cars of ore, 87,927 brake shoes were used. A set of shoes therefore lasts 20 trips.

The Utah Copper Company has seven Mallet articulated locomotives. These are of the 0-8-8-0 type. Each weighs with the tender 321 tons, and has a tractive force, compound, of 107,000 lb., and simple, of 128,000 lb. The boiler carries a pressure of 220 lb. of superheated steam. An exhaust deflector is used while passing through the tunnels, for the protection of crew and of the tunnel timber linings. To protect the engine crew against smoke while in the tunnels, the Mallets are backed up going toward Bingham; this also saves loss of time in turning the locomotive at the terminals.

One of these Mallets hauls a 50-car empty train, 1100 tons, up the grade to Bingham at 12 miles per hour, and a 50-car loaded train, 5100 gross tons, from Bingham to the mills at an average speed of 17 miles per hour. Fig. 11 shows one of these trains leaving the assembly yard at the mine. A 50-car train transports 4000 tons of ore. It therefore requires about 16 trains per day in both directions to haul 65,000 tons. The Utah Copper Company has 632 ore cars available for use. As there are always about 20 of these cars undergoing repairs, the 610 cars remaining have a capacity of about 49,000 tons. In order to handle 65,000 tons it is therefore necessary that about 200 of the cars make two round trips during the 24-hour period. But even so, the empties are delivered at the mine with surprisingly small delay to the mine operations, and returned so as to keep the mills continuously at work. Part of this efficiency is due to the physical excellence of the track over which the trains are hauled, which track has been previously described. It can be safely said that at times no more than three hours elapse from the time a load of ore leaves the shovel at the mine until a part of it is in the tailings pond at the mills. In 1928, 217,259 carloads of Utah Copper ore, aggregating 17,464,170 tons, were hauled from Bingham to the mills. This is an average of 600 carloads per day. 932 cars have been hauled in one calendar day.

The water capacity of the locomotive is sufficient for one round trip, and it carries coal for two trips. The locomotives are prepared for service at Magna where shops and enginehouses are located. Two round trips are made in 8 hours, during which time about 20,000 gal. of water are evaporated and $9^1/_2$ tons of coal consumed; this includes all stand-by losses.

Ore trains are operated continuously for 24 hours, the heaviest traffic being in the daytime. The last trains at night deliver sufficient empty cars so that the shovels can commence loading the following morning. During the day, trains in either direction follow each other at approximately 1-hour intervals, until there are six trains running, and a train in making one trip either way will meet four or five opposing trains. The necessity for the frequent passing tracks is thus apparent.

The trains of ore are set in on the load-yard tracks, of which there are three at each mill. Fifteen cars at a time are spotted at the car dumpers by 80-ton 600-volt electric locomotives, shown in Fig. 12. They are geared for a speed of $6^1/_2$ miles per hour, and can develop 32,000 lb. tractive effort. Power is supplied from an overhead catenary trolley system, supported on wooden poles, there being $8^1/_2$ miles of tracks so electrified.

Handling of the Ore at the Mills

The third operation is the handling of the ore at the mills, one of which is at Magna and the other at Arthur. At each mill there is a car dumper, the one at Magna, Fig. 13, being of more recent construction. It is of the tandem rotary type, composed of two units which may be operated separately or together, each unit handling one car, and driven by a 50-hp. motor through gear reduction. The dumper revolves through an angle of 165 deg. At Magna two loaded cars are pushed on to the dumper, emptied of their contents, and when the dumper is back to normal position the empty cars will be pushed off the dumper by the loaded cars coming on, the empty cars dropping by gravity down the empty-yard track, which has a slight grade for that purpose. In the bin under the dumper there is a grizzly built up of 20-in. T-beams, capped with manganese-steel wearing plates, the grizzly having $6^1/_2$-in. openings. The oversize from the grizzly goes through a No. 27 54-in. gyratory crusher. The combined product from the No. 27 crusher and the undersize from the grizzly is conveyed by means of two 54-in. belt conveyers to a steel hopper having grizzlies built up of standard manganese-steel T-bars spaced $1^1/_4$ in. in the summer when the ore is dry, and $2^1/_2$ in. in the

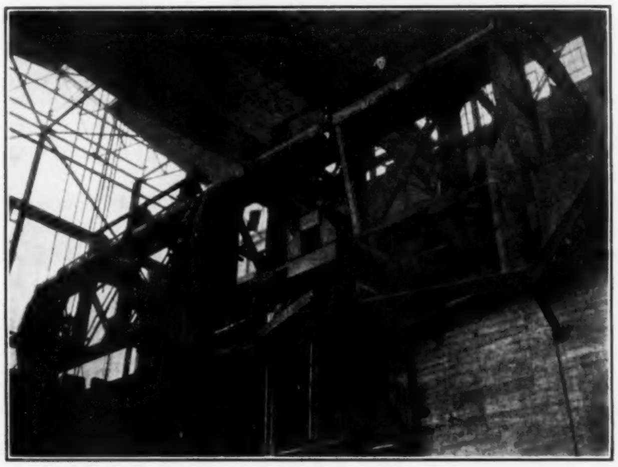


Fig. 13 Car Dumper at Magna

winter and early spring when the ore is wet. The oversize from the grizzlies goes to four No. 9 gyratory crushers (these are being replaced with Symons cone crushers), the product from which joins the undersize from the grizzlies and is conveyed on two 54-in. horizontal belt conveyors running to the secondary crushing plant; the conveyors are provided at their head ends with recording weightometers. Each conveyor discharges on an impact screen, the undersize from which is conveyed to the fine-ore storage bins. For dry ore a 1-in. × 1-in.-mesh screen is used, and for wet ore as large as $1^1/_2$-in. × 3 in. The oversize from the screens is conveyed to two 72-in. × 20-in.-rolls, the product of which is conveyed to screens having from $^3/_4$-in. square to 1-in. square mesh, and the undersize from which screens goes into the fine-ore bin, and the oversize to a 54-in. × 20-in. roll, the product from which also goes to the fine bins.

The fine bins have a capacity of about 12,000 tons or sufficient for ten hours' operation. There is also emergency storage of about 10,000 tons, which can be drawn on if the coarse-crushing equipment should be out of service. From the fine-ore bins the ore goes to the fine-grinding section, of which there are 12 units. The ore is drawn from the fine bin by apron feeders, one to each unit, and delivered to impact screens. The oversize goes to 42-in. × 16-in. rolls of which there are three to each section, and the undersize, which is approximately 8-mesh, goes to six drag classifiers. Until this stage the ore has been handled dry. Water is first added to it prior to going to the classifiers. The

overflow from the classifiers goes to flotation, and the oversize to three (in each section) 7-ft. × 10-ft. ball mills, which are in closed circuit with the above-mentioned drag classifiers. The grinding in these ball mills is such that about 90 per cent passes a 100-mesh screen. The mills use 2-in. balls cast from steel scrap in the company's foundry.

The flotation section has ten units, each unit having six rows of cells, and each row having one emulsifier, eight mechanical air roughing cells, two cleaning and one recleaning cells, all of which are of the Janney type. Flotation concentrate from the recleaner goes to two 75-ft. Dorr tanks for thickening, and the thickened product to 14-ft. American filters, of which there are four in use in the plant. The filter cake is conveyed directly to concentrate cars for shipment to the Garfield smelter. The cleaner and recleaner tails go to six 75-ft. Dorr tanks for thickening, and then return to the head of the roughers.

The overflow from the Dorr tanks goes to a settling pond, the water from which is returned to the mill circuit. This pond is in two sections to permit cleaning of one section without interrupting the use of the pond. It is cleaned every few months by flushing out and pumping the settled material back to the Dorr tanks. The tailings from the flotation roughers is carried by launders to the tailings pond, which covers approximately 9 square miles. With the exception of the rolls, which are driven from a lineshaft, each machine is driven by an individual motor. The flotation at the Arthur plant is generally the same as that at the Magna plant.

The tailings streams, containing 25 per cent of solids, flow from the mills in launders. Leaving the launders they flow naturally away from the mill sites, spreading out over the tailings that had previously been deposited in the tailings pond. The pond is enclosed with a dike built up as required, from time to time, with waste rock from the mine. The tailings are dewatered through dewatering boxes in the dike, the water running out through a canal constructed for that purpose to Great Salt Lake.

At each plant there are machine, boiler, blacksmith, and carpenter shops, each fully equipped. There is also a pattern shop and a foundry in which gray-iron, white-iron, and brass castings are made. This foundry absorbs all scrap steel, iron, and brass. Water for the milling operations is supplied through the Utah and Salt Lake Canal, 28 miles long, which gets its supply from Jordan River and Utah Lake.

The use of machines in capacious units not only results in the handling of great quantities but in doing it with a relatively small amount of labor, as shown by the following data concerning Utah Copper operations in 1928.

	Shifts	Dry tons handled	Tons per shift
Mine	585,164	31,554,510	53.9
Transportation, mine to mills	80,302	16,558,500	206.2
Mills	375,113	16,558,500	44.1

The employees at the mine and at the mills are provided with modern houses constructed by the company especially for their use.

ACKNOWLEDGMENT

The author desires here to acknowledge his indebtedness and to thank Messrs. J. D. Shilling, R. E. Corfield, F. O. Haymond, B. E. Mix, and R. E. Robinson of the personnel of the Utah Copper organization, who have assisted him in the preparation of this paper.

Blind Flying Instruction in France

THE training begins with careful study of flying instruments and is followed by work on the "training bench." This bench resembles half a barrel with two seats and controls so arranged that the student pilot can see nothing except a set of imitation instruments, and handles a set of controls which are connected to nothing at all. The student and instructor take their seats and the instructor begins to move the instruments, observing and correcting the student's countering movements.

At first the instructor moves only one instrument at a time, when it is comparatively easy for the student to follow; then he makes multiple motions of bank and turn indicators in the same direction, which is still not too difficult; and finally, movements of the two in opposite directions. After a few moments of this the average pilot finds himself very glad to get out of the barrel and take a mental rest. After a few moments of relaxation the training is begun again, accompanied by movements of the airspeed meter and fore-and-aft level, as well as of the altimeter, tachometer, and compass, and continued until the student can make the proper corrective motions with reasonable rapidity and in the correct direction.

At this point actual flight training is begun, the plane being a Farman F-71, which has been selected for the purpose on account of having no stability around any axis.

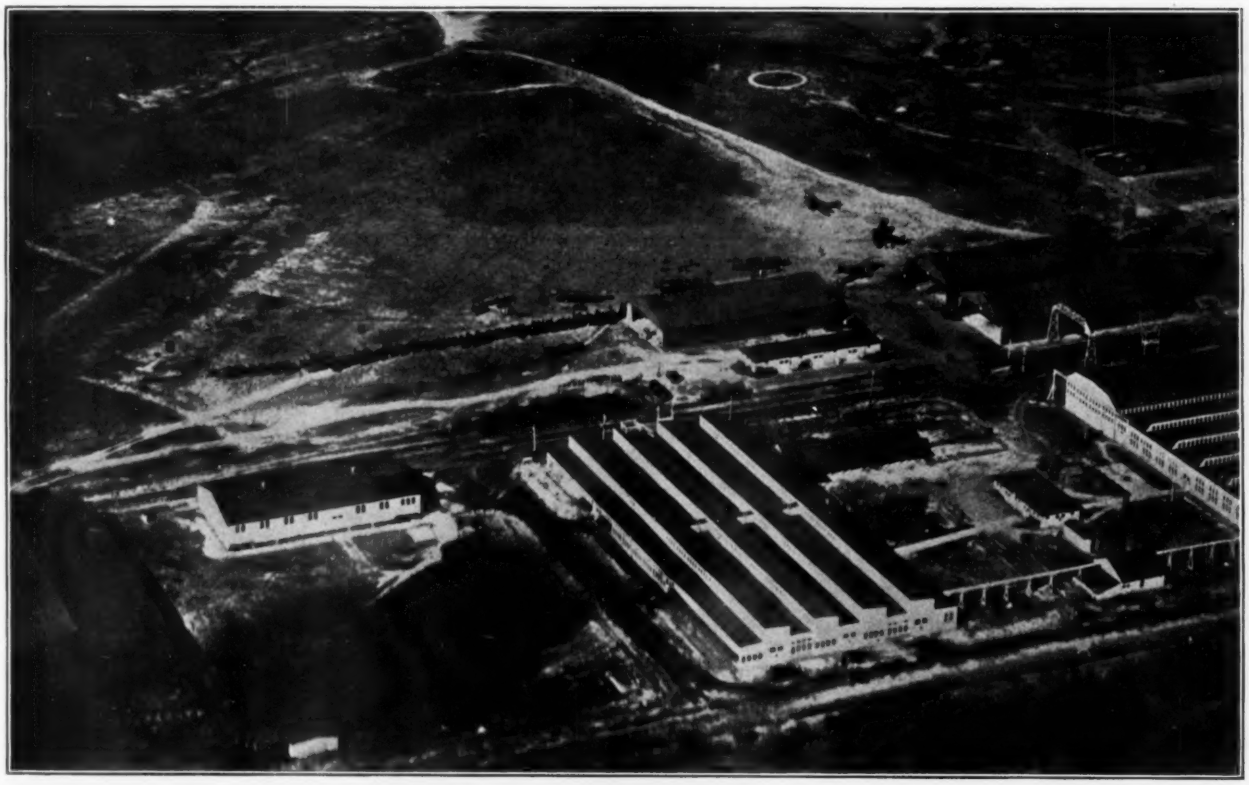
After a short normal flight the pupil is placed in the front cockpit and is covered over by a hood, the only light in which is a very small opaque deadlight, directly behind his head. The instructor takes the rear cockpit and taxies the plane on to the runway, relinquishes the controls, and opens the throttle, leaving the pupil to maintain a direct course by means of the turn indicator. It is necessary to watch closely the airspeed meter, maintaining if possible a constant rate of increase, as leveling off blind invariably results in nosing down and striking the ground.

A course is then communicated to the student by phone, and he is given an opportunity to attempt to maintain this course at an altitude of about 1000 ft.

It is generally found that after a few moments the student becomes so confused by previously acquired habits of reacting to sensations and the apparent lack of relationship between the indications of his instruments and the said sensations, that he will allow the airplane to get into what would be dangerous positions, and has to look away from his instruments and relinquish the plane to the instructor until he can reestablish his balance.

It is a strange fact that it is easier for the relatively green blind pilot to fly under the hood than in the open, for changes of light, the temptation to look at the wing tips, and the rattling of ice on the wings and fuselage, all tend to upset the equanimity of the beginner, and at times the impression of turning or banking is so overpowering that the pilot will find himself squeezed up into some corner of the cockpit, while at the same time his hand is busy apparently intensifying the abnormal flying position into which he feels himself slipping—while actually, if he is correcting according to the instruments, he is really bringing the plane back to normal flying position.

After some practice, and with confidence in his instructor, his instruments, and his airplane, the student finds himself as much at home in clouds as in clear weather, and from that time on he has no fear of his ability to go from place to place, his only concern being enough visibility near the ground to enable him to make a normal landing. (Henry J. White, Sikorsky Aviation Corp., in *Aviation*, vol. 26, no. 13, March 30, 1929, pp. 954–955.)



Maxwell Landing Field, Montgomery, Ala.
(Owned by War Department and operated by Army Air Corps; area, 302 acres; subsurface drainage.)

Fundamentals and Certain Details of Airport Design and Construction

Tendency to Underestimate Costs of Adequate Facilities—Importance of Accessibility—Drainage and Grading—Design and Location of Buildings—Lighting—Hazards—Runways—Probable Cost of an Airport

By PHILIP R. LOVE,[1] ST. LOUIS, MO.

PROBABLY no other phase of aeronautical development offers as fertile a field for the exercise of enthusiastic ignorance as does the selection and preparation of airports.

Aviation is neither a sporting proposition nor a theatrical enterprise, but a definitely and well-established transportation utility or agency, the widespread acceptance and adoption of which is as necessary today for a town or area anxious for continued growth as was similar acceptance and adoption of the railroads three-quarters of a century ago. Even the most casual observation compels recognition of the fact that the biggest and best cities are those with the best transportation facilities, which connect with the rest of the country and the world. Aviation is just one more transportation agency, and the city of tomorrow will grow with it or stagnate without it.

Most cities appear to realize this more or less clearly and are attempting to establish terminals or ports for the handling of this new form of transportation; but the whole development is so new, and so few persons have a comprehensive grasp of the elements and the needs of ports, that much loud and vigorous effort is being misapplied.

Probably as common an error as any is the tendency to underestimate the cost of adequate facilities. A good port is an investment in future growth and prosperity, and, in common with other things mundane, can be expected to pay return on the amount of the investment, and no more.

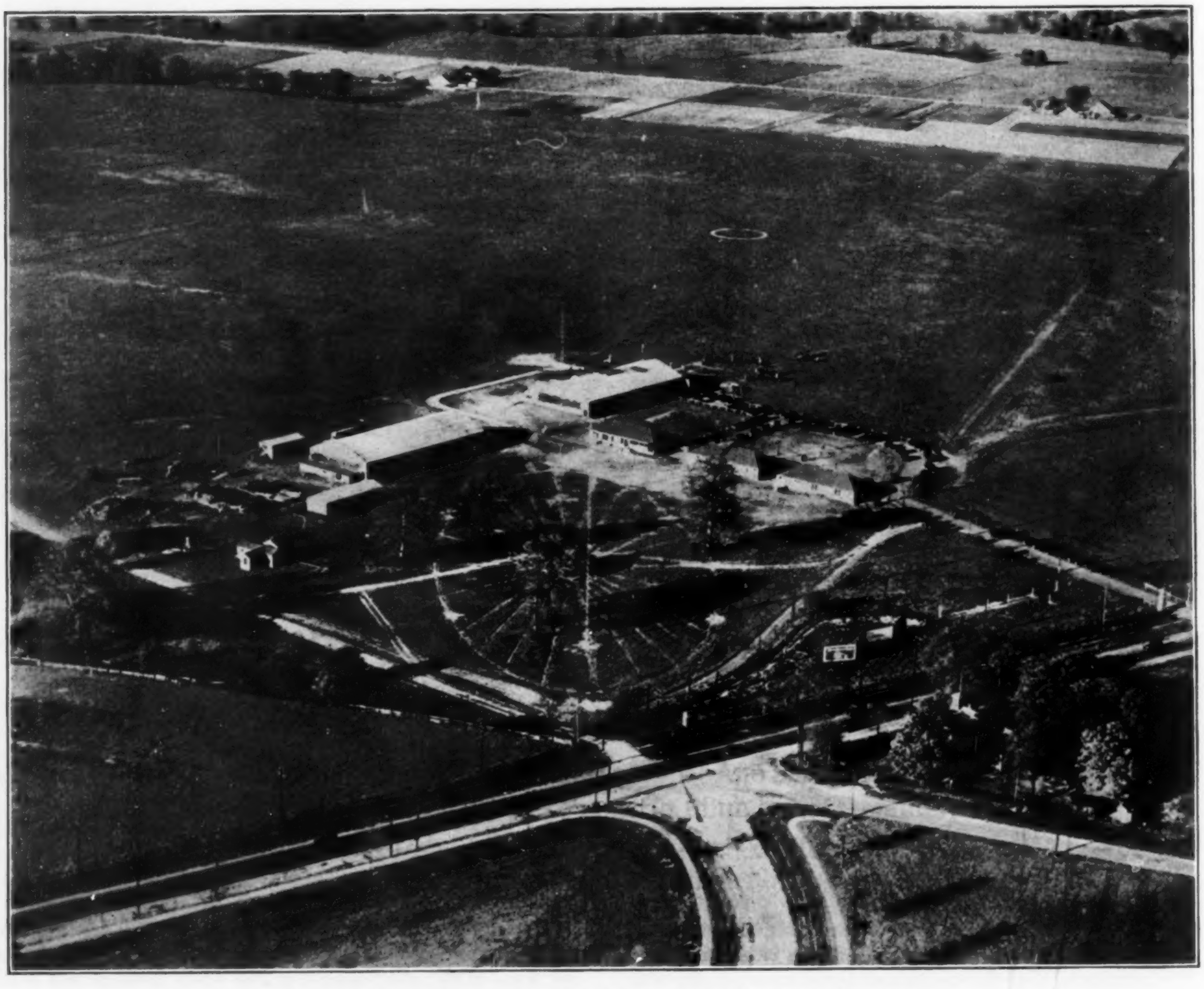
This error is most generally reflected in the unwise procurement of a port site on the basis of the price of the land. If a railroad desires a station site, a chain-store group a site for one of its stores, a theater circuit a site for a new playhouse, or any other business—except aviation—a site for the conduct of its activities, it considers the whole question from the viewpoint of attracting patronage rather than from the viewpoint of minimum cost for a certain-sized tract of land.

As long as flying is new in a community and offers allurement

[1] Love-Sultan, Inc.

Presented at the Third National Meeting of the Aeronautic Division of the A.S.M.E., St. Louis, Mo., May 27 to 30, 1929. All papers are subject to revision.

as a spectacle, people will flock to a port as to any other big free show; but as soon as it settles down—and it doesn't take long—to the routine arrival and departure of passenger, mail, and express planes flying on schedule, it must offer convenience to its potential clientele—or there will be none. The man or woman who goes into raptures over the fascination or the beauty of aerial transportation is frankly open to the suspicion of exaggerating matters, for hour after hour of flying over country which one has seen time and again is as monotonous as any other type of travel. As against this it is speedier, cleaner, and fully as comfortable as any other method, but this is soon outweighed if one has to travel long distances over indifferent roads to and from the ports at each end of the air journey.



BOWMAN FIELD, LOUISVILLE, KY., PLANNED AS A MUNICIPAL AIRPORT
(Field, operated by Army Air Corps, has an 1800-ft. north and south runway and a 2400-ft. one east and west; two radio towers 150 ft. high, and a mooring mast 75 ft. high.)

SITE SHOULD BE EASILY ACCESSIBLE FROM CENTER OF CITY

Thus it is that due consideration should be given to quick and comfortable access to town if full value is to be received from the port investment, and the search for a site should begin as close to the downtown district as possible. Nor should the fact that property happens to be occupied and used for other purposes cause it to be rejected for that reason alone, for the cost of its acquisition with the resultant scrapping of some present investment may be wholly justified by its comparative convenience of location.

Of course, it goes without saying that the fundamental requirement in the selection of any port is that of safety, for all other advantages combined cannot outweigh the disadvantage of immediate or adjacent hazards. As to what these hazards are, if one does not know and is charged with the selection of a port he had better not try to pick a site, for too many a poor devil has come crashing down in a flaming heap of shattered spars and shredded fabric on or near ports cluttered up with bordering trees, high stacks, railroad yards, high-tension lines, crowded buildings, and the like. Enough to fill many books could be written on this one phase of selection, and one could read them all and still not know the half of it. The answer is that if one has not flown in and out of ports with good ships and cranky ships, with good motors and those not so good, in good sunny weather, and in thick and blustery twilight, he should find some one who has, and then get his help.

OTHER IMPORTANT POINTS TO BE CONSIDERED IN SELECTING AN AIRPORT SITE

However, with a field properly selected as to availability to

town and freedom from immediate and adjacent hazards, one is still a long way from a sane decision until many other points or features have been weighed. Some of the principal ones to be considered are:

Avoid an area habitually clouded by smoke or frequent local fogs. Specifically, if a town is an industrial center with soft coal as the principal fuel, or one where residence heating is done with the same material, it will be found that the side toward which the prevailing winds blow will have the poorest visibility and should be avoided. Again, a river, lake, or bay on one side of the town may occasion frequent low-lying morning fogs that will completely blanket a field or port located there, and should therefore be avoided.

The Great Tempelhof Airdrome in Berlin, Germany, Showing Hangars and Passenger Planes Which Provide Service to the Principal Cities of Europe

Drainage

Another thing to consider is drainage. If the area overflows with spring-flood backwater, keep away from it. Up to within the last two or three years great stress was laid on the selection of sites as "level as a floor." Today such sites are taken only as a last resort, for they require a large sum for adequate drainage—if they can be drained at all. Basically, any field should have sufficient slope at all points to preclude the ponding of water. The ideal field in this respect is one rising gently from the midpoint in the direction of the prevailing winds. This is advantageous from an operating and lighting standpoint as well as for drainage, for it offers descending grades from the rim for the acceleration of ships taking off; ascending grades for a ship landing in midfield; and better illumination of the far side of the field from floodlights placed along one side. Contrary to this, a field with a ridge in the middle should be avoided in that the grades are wrong for either landing or taking off, the light from a unit along one side is cut off at midfield, and too pronounced a ridge introduces the possible hazard of collision of two planes on the ground and traveling in opposite directions.

Next, the soil should be observed or studied. A sandy loam with a good top soil is best, for it permits a good stand of turf and allows the absorption of rain, which serves to keep the field from getting muddy and holds the moisture necessary for good turf.

With all of these things watched, there will probably still be need for more or less subsoil drainage. Depending on the character of the soil and the turf, a goodly portion of the water falling in a hard rain can be allowed to flow off over the surface, but nearly every field will have some areas requiring porous drain lines of some sort. Clay or concrete pipe laid with open joints, preferably in rock-filled trenches, is quite commonly used for this purpose, but should be of good quality and laid deep enough in the ground to withstand crushing under the impact of landing planes. In addition to this the manufacturers of corrugated-iron pipe have developed a perforated pipe for this service. Generally speaking, this when properly installed is better than the other types; however, its cost is materially higher for lines of the same diameter, and competent analysis should be made of the soil to determine the presence of any acids which would corrode the metal, and its use avoided if such acids are present in appreciable quantities. Some manufacturers are coating metal pipe with asphalt to resist such corrosion, but this of course adds still more to the cost. One thing which should be avoided

is cast-iron or steel manhole covers or inlet gratings flush with a turf field, for the softening of the adjacent area will make sudden contact with these structures dangerous.

Another factor in connection with drainage is frost, particularly when it is coming out of the ground in the spring. This is apt to create a condition where the subsoil and subdrains remain frozen after the topsoil has become a mire. This further dictates the selection of a sloping area.

Grading and Shaping Field

With the field selected and disposal made of the drainage problem, the next step is grading and shaping. Usually there will be some portions requiring more or less grading. In general all ridges or hollows should be lowered or filled until the gradient at no point exceeds 2 per cent. In addition to this some additional grading may be required to eliminate shadows when the field is lighted from the margin. The rows in cultivated fields generally present a formidable appearance, but are not very difficult or expensive to eliminate if attacked with the proper equipment. Disk harrows and a heavy steel drag usually work the best on these—both tractor-drawn. The best disks are the "double" type with two gangs in tandem, one deflected in and one out from the center. The first time over these should be drawn parallel with the rows, and then at right angles. The best drag which has been developed for the next step is one made of structural-steel channels laid at right angles to the direction of the travel and overlapping one another like shiplap, the slope being upward to the front with the legs of the channels standing up and the front web of each channel bearing on the rear leg of the preceding member. These are fastened to side runners—also channels—with angle clips and bolts. The whole is dragged behind the biggest caterpillar tractor available, preferably the largest made, which will handle a drag about 16 ft. across and 12 ft. long, and which will put the field in excellent condition where only a small amount of work with a road machine will be required for completion.

If there is already a stand of tough but rough or irregular turf on the field or portions of it, it may be necessary to turn this over with a plow before harrowing and dragging; while if a field of corn is attacked late in the season after the roots are fully developed, the corn should be pulled instead of cut to avoid the trouble occasioned by these roots and stubbles rolling up on the surface.

If the field was originally covered with Bermuda or other equally tenacious grasses they will generally come up through and resod the area. If not, either sodding or seeding will be required. Sodding the whole area is usually out of the question, but "spot" sodding with plants on about 3-ft. intervals with Bermuda or other running grasses will give a fair stand at the end of a full season, particularly if seed is added. If the field is finished in the fall, winter wheat, oats, or rye makes a good winter crop and mother crop for grass seed planted in the spring, particularly if 200 lb. or so of sulphate of ammonia or other good fertilizer is broadcast with the seed in the spring.

Location of Buildings

The location of buildings on the port calls for the observation of a few "don'ts." Don't locate them where they must be crossed by planes, either landing or taking off, on the best approaches. Don't locate them where the prevailing winds will keep them full of dust from the field. Don't locate them in a low place where heavy rains will wash through them across the field, or so low that floor drains or plumbing fixtures cannot be given good outlets.

In general, locate them where good access to good roads leading from the port is economically available; locate them on some established and orderly plan with their faces or ends lying along a definite line instead of setting at various angles. If possible, leave sufficient room between the buildings and the edge of the port to permit of a proper landscape treatment, for the mere fact that an area is devoted to airport purposes does not mean that it must be ugly to be useful. Give thought in the grouping of the buildings to future use and to comfort—for instance, do not put a service or shop building where motors will roar on test night and day right adjacent to the administration building, pilots' quarters, or other places where reasonable cleanliness and quiet are desired. In other words, make the grouping along studied lines instead of allowing any and every one to put what they please where they please.

As to the detail and the character of the buildings themselves, "Costly thy habit as thy purse can buy, for the habit oft proclaims the man." A heterogeneous bunch of overgrown corrugated-iron shanties sprawling at will along the edge of the port will promptly discourage any substantial and attractive future development, and lower the value of all adjacent property as well.

In their eagerness to "get on the air map" many cities have done this very thing, excusing it with the vague apology that these are but temporary facilities, and that other and better ones will be provided "when the industry gets on a more stable basis." However, the first few buildings erected at a port generally establish the character of the permanent development.

As to building materials, let these be as fire-resistant as possible, and design the buildings to permit the installation of sprinkler systems at some later date if not when they are erected. Long spans and clear areas are necessary, so the best general type of construction is steel columns and trusses and light-weight roof structures such as 2-in. tongue-and-groove wood sheathing on 7-ft. or 8-ft. spans, surmounted with a good grade of built-up roofing. Many manufacturers are urging the use of crimped steel sheets covered with fiber insulation, such as Celotex, in lieu of the wood sheathing, but the cost is higher and there is honest question as to whether or not the thin sheets such as they urge will withstand fire and corrosion any better than wood. Rigid roof structures such as concrete or gypsum slabs cost much more and require much heavier and therefore more expensive supporting trusses, and are not generally recommended.

Important Features of Airport-Building Design

The structural elements of the buildings must be carefully studied and the members must be appreciably heavier than those in similar buildings located "in town" where adjacent buildings shut off much of the force of the winds, for the very nature and location of airport buildings subject them to winds with a full sweep of half a mile or more.

Another fundamental of airport-building design is to provide plenty of natural light. This means as much window area as can be obtained without sacrifice of stability or architectural appearance. Steel sash and lots of it is the best answer to this demand, and particular attention should be paid to proper design of mullions and other structural features so that they will withstand wind velocities and pressures. Also wire glass should be used for this same reason, for a properly and economically designed building will deflect and react more or less under wind action, and thin, non-reinforced glass has a tendency to break under such conditions.

Doors deserve much consideration. With the increase in wing spreads, doorways are becoming both wider and higher. Here again the wind is a real factor. On some hangars which we have built recently the doors are 120 ft. wide and 22 ft. high. To withstand the wind these doors must have the structural ability to carry a heavy horizontal load. This means heavy stiles and

rails and substantial panels, with a correspondingly heavy weight per lineal foot of door. The most generally accepted practice is to make these doors of steel, and to slide them along floor tracks on well-designed wheels or rollers. Several manufacturers have designed such wheel or roller units that permit the doors to operate around corners, and this general practice is recommended.

The color of buildings should be a light shade of buff or tan—or even white—to insure the highest possible visibility both day and night.

ing, so space will not be taken here to repeat them. These specifications also set forth the sizes and shapes needed on the fields themselves for the obtainment of the various ratings, and should be consulted before any other steps tending toward port selection and development are taken.

Lighting for Night Flying

With field and buildings both prepared, there is still another requirement before a field can be given its best rating. This is lighting for night flying, which latter is increasing very rapidly, and for which provision must be made at all good ports. The basic requirements for lighting are for boundary lights at intervals not exceeding 300 ft. completely around the field; a beacon light of certain characteristics to guide the flier to the field; a ceiling projector to determine the height above ground of the bottom of the cloud ceiling in heavy weather; red lights atop all adjacent buildings, pole lines, tall trees, or other obstacles around the port; approach lights to indicate runways or the best landing strips; an illuminated wind cone or other indicator showing wind direction; and a floodlight, or floodlights, to illuminate the landing area to a certain density. In addition to this, part or all of the buildings around the port should have their sides illuminated in their entirety and their roofs wholly illuminated or with illuminated signs thereon. Definite requirements for all of this lighting are set forth in the specifications already mentioned, and these must be followed if a creditable port is to be provided.

CRISSAY FIELD, PRESIDIO, SAN FRANCISCO, THE ONLY ACTIVE AIR SERVICE BASE ON THE PACIFIC COAST
(Reserved for Government use; private landing permitted only in emergency.)

At first, airport buildings were hard to treat architecturally, but a definite type of characteristic "airport" design is coming to the fore rapidly, and we are learning that sympathetic treatment of mass and color will give buildings a really pleasing appearance without exorbitant cost, and the whole industry has ascended to a plane where this is not only justified but demanded. Care should be taken, however, not to lean over backward in this respect in the desire to outdo the rest of the country, for after all the flying industry is like any other industry in that it must show a profit or else fall of its own weight.

The buildings required at a port vary with its location and use, but certain specifications governing restaurant facilities, sleeping quarters, toilet facilities, waiting rooms, etc., must be observed if the port is to receive a favorable rating from the Department of Commerce. Copies of these specifications, or requirements, may be obtained from the department for the ask-

Immediate and Adjacent Hazards

The problem of immediate and adjacent hazards varies with the use or uses of a port. Transport planes with heavy passenger loads both come in and go out on long, flat glides, so that the approaches to a transport field should be free from any high obstructions for an appreciable distance to obviate the necessity of either coming in high or having to pull a plane into a steep climb in taking off. An air-mail or taxi field used solely or primarily for light, fast planes, and skilled pilots does not require so much attention given to approaches, for planes in this service can come in and go out at comparatively steep angles. The third type of flying is school work, and more attention must be given to the approaches of a school field than to either of the other two, for undershooting, overshooting, or stalling on too steep a climb on take-off sometimes occasions unexpected forced landings beyond the limits of a field. Unquestionably, with the increase of all types of flying we shall soon face the need of segregating the three types, particularly on account of the hazards of school flying where the green pilot has a whole day's work mapped out for him in the handling of his own craft and cannot be trusted not to cut across the bows of a heavily loaded transport plane floating in to land. If the selection of a port is for one of these specific types of flying, the approaches and general location may be gaged accordingly; but if the field is for all types of flying activities during its first months or years, it should be laid out to the most exacting requirements.

General View of Buffalo Airport

Probable Cost of an Airport

A port wherein intelligent attention and treatment have been given to these foregoing items will cost probably at least a quarter of a million dollars for an A-1-A rating, or one on an unobstructed and unpenalized area 2500 ft. square with adequate buildings and lighting. This price tag, however, cannot be applied without study of the particular problem involved, for real-estate costs, grading, drainage, and all of the other items will vary manyfold in different locations. For instance, one field on the route of one of the transcontinental transport lines is located within a few minutes' ride of the heart of one of the largest cities of the Midwest and the property alone has a valuation of much over a million dollars, while another of the ports on which this same company is to operate, but which is located alongside a railroad right of way out in the level plains further west, is larger and better in every way, except that it is not located near a big city, but will cost but an eighth of a million in its entirety.

Unquestionably, any such amount as either of these is beyond the limit of what small cities or towns can spend. This, however, should not act as a permanent deterrent to these smaller places, for air transportation has much to offer them in its ability to connect them with the outside world, and a much smaller amount of money will provide fields or ports with limited accommodations adequate for a smaller amount of flying. With a limited amount to spend, these communities should not jump too hastily into any program, but should confer with the Department of Commerce for advice and guidance as to how to proceed.

Runways

All of the previous discussion has been based on the development of fields of the "all over" type, or ones with their full areas turfed in a manner to permit landing or taking off at any point. In many ways these are the ideal fields and, with fair soil and drainage conditions, they will stand up fairly well under a reasonable amount of flying. With the advent of the large transport ships, however, turf fields are proving inadequate. Visualize a five-ton truck speeding across a rain-soaked meadow at 70 miles an hour and the reason for this inadequacy is apparent. For such service hard-surface runways are needed, but these should be placed so as to interfere as little as possible with the "all over" use of the field by smaller planes. Location of these runways must be studied very carefully with due regard to prevailing winds, safety of approaches, and many other things.

Opinion as to the best materials for runways is varied to the extent to which manufacturing or sales organizations have different materials to sell. A man selling cinders is very confident that they make the best runways. Similarly the gravel man, the cement man, the asphalt man, and those with other materials to sell desire to see their respective products used. Each must be judged on its merits as to its adaptability to the prevailing soil and climatic conditions, and its economic availability. Generally speaking, it may be said that materials and applications suitable for highways under comparable conditions of soil, climate, loadings, and density or frequency of traffic are applicable to runways.

Another feature of airport-building design that has been slighted to date is that of heating. Our organization observed and studied hangars and shops at most of the ports in the East and Middle West during this past winter. With due deference to all of them, not a single one was found that was adequately, evenly, or economically heated. Basically, a hangar is high, wide, and not particularly handsome; has terrific heat losses due to its large glass areas; and lets all out of doors come inside whenever the doors are opened to admit or emit a ship. The most marked tendency is for heat to float up toward the roof and leave the floor unbearably cold. After studying the problem from every angle the opinion was formed that the best heating would come from the installation of extremely high-velocity, large-volume, and reasonably low-temperature units in such a manner that cold air would be taken from the floor, heated to a reasonable degree, and emitted just below the bottom chords of the trusses and at angles and velocities to jet it clear across the building to impinge on the far wall where, in cooling, it would descend and travel back along the floor to the unit for recirculation. Basically, at least six air changes per hour were deemed imperative. Several of these installations are being made this spring and summer, and this time next year we shall know how well we have answered the question.

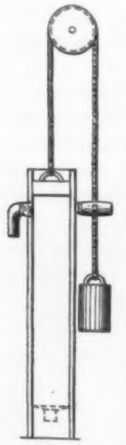
The field for discussion on every phase of port selection is limitless, but the foregoing is believed to touch on the most important features. No one phase or detail is particularly complicated or involved, but there are many of both to watch, and as each is approached there are just two possible answers to the question of whether or not the group or the individual is competent to judge and to design sanely and economically: one either knows what it is all about, or one does not. It is awfully simple if one knows, and simply awful if one does not.

Christian Huygens 1629–1695

THREE hundred years ago was born the great Dutch mathematician, physicist, and mechanical inventor, Christian Huygens, one of the most remarkable scientific investigators of all time. Born into an age when new ideas regarding the physical constitution of the universe were being discussed, in which some of nature's greatest secrets were being unfolded, and in which scientific methods of inquiry were beginning to overthrow the effete and unproductive traditions of centuries, he became one of that band of pioneers who laid firmly the foundations on which the grand edifice of science stands today. With the imagination of a Pasteur, he combined the ingenuity of a Hooke, while in the range of his investigations he has been excelled by few. In his own lifetime his reputation was international, while today he is recognized as the connecting link between Galileo and Newton. In a country which can boast of a Snell, of a Leeuwenhoek, of a Boerhaave, a Swannerdam, a Buys-Ballot, and a van der Waals, no name is held in esteem higher than that of Huygens.

The life of Huygens was one devoted almost entirely to study. Of distinguished parentage, he was able from first to last to follow his own inclinations which happily, like those of our own Joule, led him to devote himself to the advancement of knowledge. His father, Constantin Huygens, was the poet and diplomatist who was knighted by James I in 1622. It was seven years after, on April 14, that the famous son was born. Educated first at home, Huygens studied at Leyden and at Breda, and, for a time, was attached to the Dutch Embassy in Denmark. In his student days, the chief philosophical instruments were the telescope, the air pump, the barometer, and the primitive electrical machine. It was to the first of these that he early turned his attention, and after the publication of some mathematical tracts he began, in 1654, with his brother, the construction of astronomical telescopes and on March 25, 1655, he made his discovery of Titan, the sixth by order of position, but the first seen of Saturn's satellites. Saturn's curious appearance, as first noted by Galileo, which had led to its being called the "triple planet," was still unexplained; but in 1655, Huygens came to the conclusion that the planet was surrounded by a flat ring. This discovery he made known in the form of cipher which ran: "aaaaaaa ccccc d eeeee g h iiiiiii llll mm nnnnnnnnn oooo pp q rr s ttttt uuuuu." He afterward restored the letters to their original places, where they stood thus: "Annulo cingitur, tenui plano, nusquam cohaerente, ad eclipticam inclinato," or, in other words, "The planet is surrounded by a slender flat ring, everywhere distinct from its surface, and inclined to the ecliptic." His method of publishing his discovery was that often followed in the seventeenth century, and Hooke first published his well-known law in this form. This theory, though received with amazement, explained all the phases of Saturn, and the ring today is still regarded as a unique celestial phenomenon. From improvements in telescopes Huygens turned to improvements in clocks, which, for two or three centuries, had included the old verge escapement and the foliot balance. Huygens, on June 6, 1657, presented the first pendulum clock to the States General, and with that invention began a new epoch in horology. His tract "Horologium" of 1658 contains a description of his improvement, but his much more famous work "Horologium Oscillatorium" did not appear till 1673. About 1660 he appears to have made two visits to England, and, with his countryman Mercator, is said to have observed the Transit of Mercury of May 3, 1661, from a house

in Long Acre, London. His reputation now led Colbert to invite him to Paris, and from 1666 to 1681 he enjoyed the patronage of that great statesman. His name was already on the roll of the Royal Society, and he became the first foreign associate of the Paris Academy of Sciences. Living in the quiet seclusion of the Royal Library, Huygens assiduously pursued his studies, and, in 1673, produced the great work already referred to. In this he dealt with pendulum clocks, the descent of heavy bodies, with evolutes and involutes and their properties, with the compound pendulum, and with centrifugal forces. About the same time as Hooke he suggested the use of a balance wheel in watches, and the first watch with such a mechanism was made in Paris and presented to Louis XIV. With his papers on the collision of bodies, his treatise on light, in which he first enunciated the undulatory theory, and his speculations on the universe, it is impossible to deal.



Of more especial interest to engineers is his invention of the gunpowder and air engine, the first motive engine or prime mover with a cylinder and piston utilizing the greater pressure of the atmosphere acting against the lesser pressure of a partial vacuum. Huygen's work is in direct line with the discoveries of Torricelli, Otto von Guericke, Boyle, and Hooke, and the inventions of Savery, Papin, Newcomen, and Watt. It was in 1680 that Huygens read his paper, "A New Motive Power by Means of Gunpowder and Air," to the Paris Academy of Sciences. The engine [see sketch in adjoining column] consisted of a hollow cylinder, well polished, a piston with water on top to help seal it, an explosion chamber at the bottom of the cylinder which was placed vertical, and ports in the cylinder near the top fitted with leather tubes which acted as non-return valves. A rope attached to the piston ran over a pulley, and from the other end weights were suspended. The explosion of the powder drove the piston upward. The rapid cooling of the gas led to the formation of a partial vacuum and the pressure of the air drove the piston downward, causing it to lift weights. It was Papin who suggested the use of steam instead of powder, Savery who patented the principle of the condensation of steam but applied it in a different manner, and it was Newcomen who produced the first practical atmospheric engine from which all later types of piston steam engines have come.

Huygens remained in France only one year after the reading of his paper on the new motive power, and returned to Holland in 1681. He visited England in 1689, published his "Traité de la Lumière" in 1690, and spent the evening of his life writing his "Cosmotheros." Never married, he died at The Hague on June 8, 1695, and, like Boerhaave, is buried there in St. Peter's Church. —Engr.-Capt. Edgar C. Smith, O.B.E., R.N., in *Engineering*, April 12, 1929, p. 452.

Annual Report of Engineering Foundation

A SCIENCE of humanics should be built up by research, it is declared in the annual report of the Engineering Foundation, made public by Director Alfred D. Flinn at 29 West 39th St., New York, N. Y.

"Experience," says the report, "is showing year after year the actual usefulness and the much greater possibilities of this joint research organization of our four senior national engineering societies with their 60,000 members.

"Even with small and uncertain resources, many members of these societies on special research committees are making valuable contributions of knowledge for the betterment of engineering and industrial practices. The public benefits, generally unaware.

"Research interests of engineers are not restricted to so-called material things. Improvement of the facilities for living and communicating lifts life steadily to higher intellectual, moral, and spiritual levels, and promotes health, happiness, and brotherliness. The engineer's studies must include the effects of his technical activities upon his fellow humans and their social organization."

During the year, according to the report, the Foundation continued its aid to researches concerned with arch dams, concrete arches, steel columns for bridges and buildings, blast-furnace slags, electrical insulation, lubrication, engineering education, and painting of wood.

It also aided studies of fluid flow, cutting fluids used in cutting metals, engineering vocational selection, and other structural problems. Two new research projects are now under way. One relates to alloys of iron, and will embrace all forms of irons and steels. The other involves the materials, manufacture, and use of wire ropes.

"During the centuries of the iron age," the report points out, "man has learned some facts about iron and steel. Much literature has accumulated and is accumulating in many places and languages. Unfortunately not all of it is good.

"A great deal of valuable information is not accessible to thousands of persons who should be utilizing it daily. Man needs to know many more facts about iron and its combinations with other substances. A great public service can be done along these lines."

Following a conference of forty representatives of twenty-nine corporations and other organizations called by the American Institute of Mining and Metallurgical Engineers, a plan for cooperative research in alloys of iron was mapped out. The Institute appointed a Committee on Alloys of Iron Research to serve in an advisory capacity. The chairman is John Johnston, Director of Research and Technology, U. S. Steel Corporation.

"Preliminaries have been developed by competent men," the report continues. "The next steps can be taken as soon as assurance of funds is obtained. From its modest resources the Engineering Foundation has appropriated $10,000, besides paying initial expenses.

"Everybody will be benefited in some measure, but more directly and tangibly: producers of irons and steels, producers of alloys and alloying elements, the railroads, manufacturers and users of automobiles, trucks and tractors, aircraft industry, builders and users of heavy machines, machine tools, electrical equipment, Diesel engines, turbines, locomotives, petroleum industry, iron and steel foundries, makers and users of wire ropes and cables.

"An Endowment Committee, appointed by the United Engineering Society for the Founder Societies has for members sixteen prominent engineers, with Colonel E. A. Simmons, member of the American Society of Civil Engineers and The American Society of Mechanical Engineers, as chairman.

"This Committee is seeking $5,000,000 for the Engineering Foundation, and $2,000,000 for the Engineering Societies Library by direct gifts of cash or securities, bequests, life insurance, annuities, living trusts, or instalment contributions."

Corrosion of Metals as Influenced by Surface Films

By F. N. SPELLER,[1] PITTSBURGH, PA.

This paper reviews briefly the more important facts developed on the influence of metal-surface films on corrosion. This is evidently one of the principal factors in nearly all types of corrosion.

Films and surface protective layers formed mainly by external reagents, such as passivifiers, are first discussed.

The influence of well-known alloying metals on the film-forming capacity of iron is also discussed, and the conclusion is reached that rust-resisting alloys, such as high-chrome iron and "stainless steel," probably owe their resistant properties to the stable films formed under certain conditions, and therefore that the life of these metals is more directly dependent on the stability of the film formed than on the initial tendency of the metal to corrode. Some metals evidently have much more of this self-protecting property than others.

THAT the corrosion problem is not a product of the age of steel is clear by reference to the engineering literature of the early part of the past century. The deterioration of cast-iron water mains was causing concern in France in 1830, and extensive investigations were made leading up to a very thorough piece of research work by Robert Mallet extending from 1838 to 1843.[2] Incidentally cement lining of water mains which has been rather widely advocated in recent years was first suggested and used in 1836 for the protection of cast-iron pipe. Of course this problem has become of increasing importance with the increased use of corrodible metals, and there is no doubt that the preventable waste resulting amounts to several hundred millions of dollars per annum. For instance, carefully compiled data indicate a loss of one hundred and twenty millions a year in the American petroleum industry."[3] A considerable part of this and similar waste can be changed from a liability to a national asset.

Although this problem has long been known to be serious, only recently have the fundamental controlling factors received close scientific study. The present paper deals with one of the most important phenomena of the corrosion of metals, viz., natural surface films and layers of various thicknesses which form on clean metals by reaction with external agencies.

The electrochemical theory of corrosion is now generally accepted in explanation of the initial corrosive attack at normal temperature. At higher temperatures and occasionally at temperatures not far above normal, direct chemical attack may occur. The initial corrosive reactions when metal is first exposed in contact with water and oxygen are:

I. $M \text{ (metal)} + 2H^+ \text{ (ionic)} = M^{++} \text{ (ionic)} + 2H \text{ (atomic)}$

II. (*a*) $2H \text{ (atomic)} + {}^1/_2O_2 = H_2O$

(*b*) $2H \text{ (atomic)} = H_2 \text{ (molecular)}$

The result of these reactions is that the solution tends to become alkaline at cathodic areas and acid at the anodes. Most metals when first exposed to water show initially a high rate of solution which quickly slows down as the polarizing film of hydrogen forms on cathodic areas. Obviously, the reaction can only continue by removal of the atomic-hydrogen film either by combination with free oxygen or as hydrogen gas.

In case corrosion products are insoluble, surface films form which greatly retard and sometimes stop the reaction. The metal surface may thus become completely covered with a film of corrosion products ranging in thickness from an atomic layer to measurable dimensions. These films may form on anodic or cathodic areas. After a film forms over an anodic area the potential may be reversed, and this change of potential may occur repeatedly, resulting in fairly uniform corrosion.

Ordinary corrosion is dependent upon the maintenance of a supply of free oxygen and water at the metal surface and is largely influenced by temperature, rate of motion, hydrogen-ion concentration, local changes in potential due to oxygen concentration cells or dissimilar metals in contact, protective films, and many other variables. The retardation of corrosion is most generally brought about, however, by the formation of more or less impermeable protective films on anodic areas. These films start to form shortly after the metal comes into contact with a corroding medium. They consist essentially of the products of corrosion and attain their maximum protective power after a certain period of time. This may be looked upon as a self-healing property of some metals, without which they could have a considerably higher rate of deterioration and be much less useful. It should be our aim to cultivate this valuable property in metals. In fact, it seems to the author that metals having high corrosion resistance may be better developed by a scientific study of the stability and formation of surface films than by the old cut-and-try method of making and testing the effects of various alloying elements. Some work has already been done on the study of the electrical resistance of these films, but more knowledge of the *initial rate* of attack and the rate at which corrosion is retarded by the alloying of certain elements with iron should be helpful in explaining the mechanism of the resistance to corrosion.

A protective surface film may be formed on clean metal, like iron or aluminum, when exposed to certain external film-building reagents such as chromic acid or oxygen, or the film may be formed in virtue of the presence in the metal of a sufficient amount of other elements such as chromium or silicon, the oxides of which form with the oxides of iron a corrosion-resisting layer. The compound oxides are often more resistant than single oxides; at least this is true in the case of oxides of iron and chromium.

Taking up the first group of protective films or layers we have:

High-Temperature Oxidation. The work of Pilling and Bedworth[4] is well known. They found that certain metals increased in weight at a decreasing rate when exposed to air at elevated temperatures, and that below a certain critical temperature an equilibrium was established so that no further oxidation occurred. On some steels these oxide films are more or less permanent up to 900 deg. cent., but at 1000 deg. cent. the oxide layer begins to break down. The resistance of metals to high temperatures is therefore due to the property they possess of forming a more or less durable film that is impervious to oxygen below

[1] Metallurgical Engineer, National Tube Co. Mem. A.S.M.E.

[2] Reports of the British Association for the Advancement of Science, for the years 1838, 1840, and 1843. Abstracted by Charles W. Sherman, Jr., N. E. Water Works Assn., vol. 42, no. 3, pp. 261–265.

[3] Report of American Petroleum Institute Temporary Committee on Corrosion, Am. Pet. Inst. Bull., p. 245, vol. IX, no. 7, Jan. 31, 1928.

Presented at a joint session of Section C (Chemistry) and Section M (Engineering) at the Fifth New York Meeting of the American Association for the Advancement of Science, December 28, 1928.

[4] N. B. Pilling, and R. E. Bedworth, *Jl. Inst. Metals*, vol. 29 (1923), pp. 529–582; discussion, 583–594.

a certain temperature. Any break in the oxide layer results in further attack, and if the temperatures is below the critical point a healing oxide again forms. This being true, we should expect to find a low endurance limit under repeated stresses at temperatures that rapidly cause a surface film to form by oxidation. The resistance of metals to elevated temperatures is evidently due to the character of the oxide film produced.

Surface Films Formed at Normal Temperature. Similar film protection is formed at temperatures approaching normal under considerable longer exposure. The author reported observations on some French iron and steel pipe that had not shown serious corrosion in the atmosphere on the Isthmus of Panama.[5] However, when these specimens were cleaned by machining and again exposed, they corroded like modern steel treated in the same way.

Evans[6] reports an investigation which he made on some old galvanized-iron roofing sheets which had resisted weather conditions successfully for fifteen years exposed to sea spray in the Scilly Islands. He showed definitely that the older material was more resistant than new galvanized sheets, and that this was due not to any essential difference or superiority in the older zinc coating but to a permanent protective film that had evidently been acquired during the initial period of exposure. There is considerable evidence like this pointing to the fact that the conditions prevailing when the metal is first exposed have much to do with its subsequent life, depending apparently upon the character and adherence of the early products of corrosion.

Evans (ibid.) artificially produced a protective film on a zinc surface by alternately spraying with N/100 sulphuric acid or N/2 sodium chloride and drying, which increased the resistance of the metal when partially immersed in N/2 sodium chloride.

Action of Acid Inhibitors. Certain inhibitors reduce the rate of solution of metals in acid solutions. It has been shown that this is due to an increase in the hydrogen overpotential which is generally assumed to be due to formation of a film of discharged inhibitor substances adsorbed on the cathodic areas. The theory of inhibitor action has been well stated by one group of investigators as follows:[7]

> When immersed in acid, iron goes into solution at the anode areas, forming ions and discharging hydrogen ions at the cathode areas. These cathode areas may be said to occur principally in the narrow spaces of the grain boundaries in steel, or between the metal and slag in wrought iron. Most inhibitors are either bases, such as quinoline, or positively charged colloids, and when these are present they travel to the cathode areas with the hydrogen. When the positively charged heavy particles are discharged, they cannot escape by gaseous evolution and accordingly are adsorbed on the surface, building up a protective layer.

Other Examples of Film Protection—Passivity. Another well-known example of film protection is found in the action of alkalis in solution. Some work done by the author and one of his associates[8] a few years ago, indicated that the initial rate of corrosion of iron in water having various concentrations of caustic soda did not vary materially, but that several minutes later the corrosion rate decreased to a minimum depending upon the hydroxyl concentration. This is explained by the lower solubility of ferrous hydroxide in the more alkaline solutions and the greater tendency to form a substantial protective layer of the products of corrosion under such conditions.

By controlling the pH in domestic water supply with respect to the bicarbonate of calcium in solution, the reaction

$$Ca(HCO_3)_2 + (CaOH)_2 = 2CaCO_3 + H_2O$$

results, producing a protective layer consisting largely of calcium carbonate.

The relationship between the equilibrium values for alkalinity expressed as calcium carbonate and the pH value in distilled water and in Baltimore tap water has been plotted from experimental data obtained by Baylis.[9] For any definite alkalinity a calcium carbonate scale tends to form when the pH value is raised above the equilibrium value for any particular water. This method of controlling corrosion and preventing "red water" was successfully put into practice in the city of Baltimore.

Sodium silicate has been found useful in some waters to assist in building up protective layers consisting of the products of corrosion, silicates and carbonates from the water; as little as 10 p.p.m. is sufficient in some cases to prevent "red water."[10] The solution of lead may be stopped by the use of a small amount of soluble silicate in the same way. Silicate layers build up slowly and break down after a certain period of time when the water treatment is discontinued. May and Carpenter[11] give some interesting examples of the building up and repair of broken surface films on non-ferrous condenser tubes, and trace the formation of these films by a series of measurements of the film potential.

Passivity is induced in iron and ferrous alloys, zinc, aluminum, copper, and other metals when they are subjected to the action of strong oxidizing reagents such as strong nitric acid, chromic acid, or a rather strong solution of chromates. A metal may also be rendered passive to corroding reagents by anodic attack. To form such a film, the voltage must be sufficiently high to cause evolution of oxygen at the anode.

As long as a certain concentration of the passivifying reagent is in contact with metal, it is kept immune from attack under the action of corrosive solutions and alternating stresses that in the absence of the inhibitor would cause rapid destruction of the metal. McAdam[12] has shown that the endurance limit of iron and some other corrodible metals is greatly reduced by the combined action of cyclic stresses and corrosion produced by a stream of water impinging on the stressed specimen. We have shown that 200 p.p.m. of sodium chromate in ordinary tap water will completely overcome this effect, evidently by maintaining the protective film.

In reporting these experiments particular attention was called to the fact that a narrow band of lacquer or loose rubber surrounding the test piece caused failure evidently due to a localized acceleration of corrosion sufficient to overcome the passivifying effect of the inhibitor, which otherwise gave good protection under the same stress.

All these observations and experiments by inference point to passivity as being due to invisible film protection. Evans[13] showed that some of these invisible passive films may be raised off the metal surface and rendered visible.

It is not surprising that these very resistant films are so thin

[5] F. N. Speller, Discussion, Proc. Am. Soc. Test. Materials, vol. IX (1909), p. 440.

[6] Ulick R. Evans, "Corrosion at Discontinuities in Metallic Protective Coatings." Presented at Liverpool, Eng., Institute of Metals, Sept., 1928.

[7] E. L. Chappell, B. E. Roetheli, and N. Y. McCarthy, "The Electrochemical Action of Inhibitors in the Acid Solution of Steel and Iron," *Ind. & Eng. Chem.*, vol. 20, June, 1928, p. 596.

[8] F. N. Speller and C. R. Texter, "Effect of Alkaline Solutions on the Corrosion of Steel Immersed in Water," *Ind. & Eng. Chem.*, vol. 16, no. 4, Apr. 1924, pp. 393–397.

[9] John R. Baylis, "Prevention of Corrosion and 'Red Water,'" *Jl. Am. Water Works Assn.*, vol. 15, no. 6, pp. 598–633, June, 1926.

[10] F. N. Speller, "Corrosion—Causes and Prevention," p. 350 (McGraw-Hill Book Company, 1926).

[11] R. May and H. C. H. Carpenter, "The Corrosion of Condenser Tubes." Presented at Liverpool, Eng., Inst. of Metals, Sept., 1928.

[12] D. J. McAdam, Jr., "Some Factors Involved in Corrosion and Corrosion-Fatigue of Metals," Am. Soc. Test. Materials, June, 1928.

[13] Ulick R. Evans, "The Passivity of Metals, Part I. The Isolation of the Protective Film," *Jl. Chem. Soc.*, 1927, pp. 1020–1040.

as to be invisible, as corrosion under these conditions is quickly arrested and the growth of the film must then cease. Evans (ibid.) has shown that oxygen uniformly distributed tends to passivify iron. This may explain the abnormal resistance occasionally found in old iron or steel, zinc-coated material, and other metals. Alternate wetting and drying in a warm atmosphere apparently brings this about, provided it happens in a favorable cycle before very active corrosive conditions occur, such as a long foggy spell of weather. On the other hand, we have found that variations in oxygen concentration have a marked tendency to break down protective films. There is, therefore, good ground for considering passivity of all kinds, including the slow corrosion of steels resistant to corrosion, as due to film protection.

The accelerating influence of contact between dissimilar metals may be offset more or less by the use of passivifying reagents.

In practice it is most economical to use sodium dichromate with sufficient caustic soda to form the normal chromate. This compound may be used to stop corrosion in water-cooling systems where the water is recirculated over and over. About 200 p.p.m. of the dichromate is usually sufficient in such cases, although the amount required varies with the composition of the water, particularly the chloride contents. This treatment is also useful in retarding the action of refrigerating brines on plain and galvanized steel. A 20 per cent brine requires 1500 p.p.m. of dichromate and 400 p.p.m. of NaCH. Naturally the surface film is harder to maintain in high-chloride solutions, but experience for over a year at several ice plants has demonstrated the practical value of this treatment by which the corrosion of equipment is reduced by 80 per cent.[14]

Metals Resistant to Corrosion. Having considered a few examples of unstable metals which may be made less corrodible by the formation of a protective layer on the metal surface without any change in the metal itself, let us now consider what can be done toward prolonging the life of the metal by alloying it with other metals.

When the electrolytic theory was first discussed, some were misled to the conclusion that a high degree of purity and a more homogeneous structure would give much longer life to ordinary steel. Greater purity of the metal has not proved to be the answer except under acid attack. We now know that external factors usually control the rate of corrosion, and that all commercial grades of iron are much alike in being naturally more corrodible under some conditions than metals like chromium, nickel, silicon, or copper, for example. Fortunately, iron can alloy with a large proportion of these more resistant metals, forming solid solutions that are much more resistant in many cases than the alloying metals themselves. The essential characteristics of a rust-resisting metal are apparently that it should have a low solution pressure and form impermeable, tenacious, and stable films in combination with corroding media. These films should be and are usually much more stable than the metals which enter into their structure, but as they are attacked differently under different conditions it is not to be expected that a metal will soon be found that is equally resistant under all conditions. Gold and platinum are at present the only metals that are resistant to nearly all corroding reagents.

Take the case of steel with the addition of $^1/_4$ of 1 per cent of copper, which is now well established commercially. Long-time exposure tests in service have shown an increased life of from two to four times in atmosphere by the addition of this amount of copper to ordinary bessemer steel, whereas the same steel under water or in corrosive soil is apparently no better than ordinary steel without copper. In the former case, when the metal first goes into solution, copper is precipitated *in situ* and a double oxide of copper and iron formed. In water, on the other hand, the rust is loosely formed and not so dense, suggesting that the small amount of copper is carried away from the corroding surface when the metal dissolves, and therefore plays no part in the formation of a protective layer.

For most purposes where large tonnages of metals are involved, the world is interested in the use of iron as a base for a more durable metal having useful physical properties. Small additions (1 or 2 per cent) of chromium, nickel, or silicon to iron have not given encouraging results, but when the amount of chromium or silicon exceeds 12 or 14 per cent a very marked stability is produced, particularly under atmospheric exposure or where the metal is exposed to strong oxidizing conditions. This amount of chromium in solid solution in iron forms a very resistant oxide film which is self-healing except under those conditions (as in the presence of an excess of chlorides) where the film is destroyed. High-chromium iron when immersed in copper chloride solution after careful cleaning *in the absence of oxygen* goes into solution and precipitates copper like ordinary iron. The addition of 8 per cent or more of nickel still further increases the stability of the surface film under a wider range of conditions. An attractive field of research is open in the study of the stability of films made up of combinations of oxides. More fundamental information is also desirable on the initial rate of corrosion of these alloys, which latter appears to depend upon the type of anodic film protection produced in the corroding media.

These are fundamental problems worthy of the close attention of physical chemists. The nature of the bond which holds these passive films on the metal is also an interesting field of speculation. It may be, as Guertler[15] points out, that the unsatisfied attractive bonds of the surface atoms of the metal bind oxygen atoms to the metal and thus form a primary protective layer (an atomic priming coat as it were) to which a more protective oxide layer is often attached.

High-chromium steel (stainless steel) has been shown by Friend[16] to resist the action of sea water very much better than ordinary steel similarly exposed, except where the samples were partially protected in a wooden rack. All the metals so protected were deeply corroded at that place, probably due to the difference in oxygen concentration. Small particles of scale on the surface of chrome-iron also induce a difference of potential which results in pitting, so that to get the best results the metal should be polished. High-chromium steel is also subject to pitting in corrosive soils. This and other circumstantial evidence points to the conclusion that the superior resistance of such steels is due to the stability of the surface film formed rather than to any great reduction in the solution pressure of the metal by the chromium addition. It is also significant to note in connection with the question why certain steels are much more durable than others in certain media, that high-chrome-iron and steel are 10 to 20 times more durable than ordinary steel when immersed in fresh water saturated with air, but when subject to a large number of cycles of stress in contact with water they show less than twice the durability of ordinary carbon steel. Some recent experiments in our laboratory indicate that when a band of rubber is placed around a high-chrome-iron test piece while under stress so as to cause a local difference in oxygen concentration, the endurance limit is still further reduced. As the life of this steel is so materially influenced by small variations in surface potential, the surface-film hypothesis seems highly probable.

All this being true, it follows that to improve the durability of

[14] *Refrigerating Engineering*, July, 1928, p. 22.

[15] Wm. M. Guertler, "The Corrosion of Metals," Trans. Am. Soc. for Steel Treating, vol. XIII, no. 5, pp. 759–794, May, 1928.

[16] J. N. Friend, "Results of Four Years' Exposure in the British Channel," Carnegie Scholarship Memoirs, vol. XVI, pp. 131–151, 1927.

iron, for instance, the procedure would naturally be to first investigate the compounds of iron and other metals that are most resistant under certain conditions of service, then select the most likely ones and endeavor to form solid solutions of iron and other metals that will form these resistant films when the metal corrodes. The alloying metals available in practice include principally copper, nickel, chromium, silicon, and aluminum. As double compounds of these metals are as a rule more stable, a research of this kind is likely to take some time and patience. However, much has already been learned by experience, and useful alloys of iron, chromium, and nickel are now available for various purposes where first cost is of secondary importance. A low-priced alloy is needed which will be two or three times as durable as ordinary iron in air, soil, or natural waters without much additional cost. Experience with the iron-chromium, iron-nickel, and iron-silicon series points to the necessity of a large amount (over 13 per cent) of these alloying metals in solid solution, and does not offer much promise of the early development of a low-cost rust-resisting iron alloy.

Aluminum may be mentioned as an illustration of a metal that quickly forms a stable oxide film and on this account possesses high resistance to atmospheric corrosion. In contact with chloride solutions this film is soon penetrated and destroyed, and in consequence under these conditions the metal has a comparatively short life. Aluminum in larger amounts (perhaps with other metals) may prove to be a useful alloying agent in iron for certain kinds of exposure.

Variations in water, local differences in surface potential, and other factors may affect the stability of the film formed on metals, so that tests should be made under service conditions or by using the same controlling factors that are found in practice. Too often the impatient investigator resorts to an acid test, and misleading statements are prematurely published which tend to discredit other work. Popular advertising of special alloys of iron with a dash of this or that and a cryptic name should be viewed with suspicion until satisfactory tests under specific conditions of service are obtained. So far no low-priced iron alloy has been put on the market that seems worth the difference in cost except for atmospheric exposure, and ordinary bessemer steel with a little copper seems to be as durable as any other for this type of exposure.

Much has been done, however, to minimize corrosion by control of external conditions, by improved methods of protecting the metal from corroding agencies and by the use of rust inhibitors.

Stresses in Heavy, Closely Coiled Helical Springs Axially Loaded

BY A. M. WAHL,[1] EAST PITTSBURGH, PA.

This paper gives more exact formulas for calculating stresses in heavy, closely coiled helical springs axially loaded. It is shown both analytically and by test that the commonly used spring-design formulas as well as the commonly used spring tables may be as much as 60 per cent in error in practical cases. Experimental means for checking up the new formulas are described, and their practical meaning is discussed.

THE frequent failures of heavy helical springs, especially those having a comparatively large wire diameter relatively to the coil diameter, has been a much discussed topic in engineering circles within recent years.[2] Huge sums of money are expended annually by the railroads of this country to replace helical springs which have broken in service under loads which were supposedly well below the safe loads determined by the commonly used spring-design formulas or tables, the properties of the spring material being known. Just why these springs should fail under these supposedly low stresses has remained more or less a mystery.

With these facts in mind, a recent investigation on stresses in heavy, closely coiled helical springs carried out at the Westinghouse Research Laboratory is particularly pertinent. This investigation shows quite conclusively that the true maximum stress in springs of this type in many practical applications may be from 40 to 60 per cent greater for a given axial load than the stress given by the commonly used spring-design formula, or by the spring tables now in common use. This large error comes about chiefly because, as will be seen later, the ordinary formula is derived by disregarding the difference between the fiber lengths at the inside and outside of the coil.

STRESS FORMULAS FOR HEAVY HELICAL SPRINGS

Consider an element $aa'bb'$ [Fig. 1(b)] of the coil of a heavy helical spring under an axial load P. Under the action of the twisting moment Pr the two neighboring radial cross-sections aa' and bb' will rotate with respect to each other. But since the length of the fiber $a'b'$ is much less than that of the fiber ab, the unit shearing strain, and hence the unit shearing stress, in $a'b'$ will be much greater than that in ab. In addition the stress in $a'b'$ is further augmented by the direct shearing stress due to the axial load P. In the case of the springs tested as explained below, the shearing stress in the fiber $a'b'$ was found experimentally to be nearly $2^1/_2$ times that in the fiber ab, a surprising difference when it is remembered that the ordinary formula assumes the stress in $a'b'$ to be the same as that in ab.

By making certain assumptions with regard to the rotation of the sections aa' and bb' it is possible to derive an approximate analytical expression for the shearing stresses in the extreme fibers, which expression for the shearing stress in the fiber $a'b'$ is:

$$S_{max} = \frac{16Pr}{\pi d^3}\left(\frac{4c-1}{4c-4} + \frac{0.615}{c}\right) \qquad [1]$$

In this expression:

P = axial load on spring
r = mean radius of coil = $^1/_2$ mean diameter
d = wire diameter
c = $2r/d$ = ratio of mean coil diameter to wire diameter.

[1] Research Laboratory, Westinghouse Elec. & Mfg. Co.

[2] This question is discussed in a paper by G. M. Eaton, "Design from a Heat-Treating Standpoint," Trans. A.S.S.T., Nov., 1927.

Contributed by the Research Special Committee on Mechanical Springs and presented at the Annual Meeting, New York, December 3 to 7, 1928, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Abridged.

NOTE: Statements and opinions advanced in papers are to be understood as individual expressions of their authors, and not those of the Society.

We see that this formula is simply the commonly used formula for stress in a heavy helical spring, i.e., $16Pr/\pi d^3$ multiplied by a factor which is always greater than unity and which depends only on the ratio c of mean coil diameter to wire diameter. A graphical representation of this equation is given in Fig. 2.

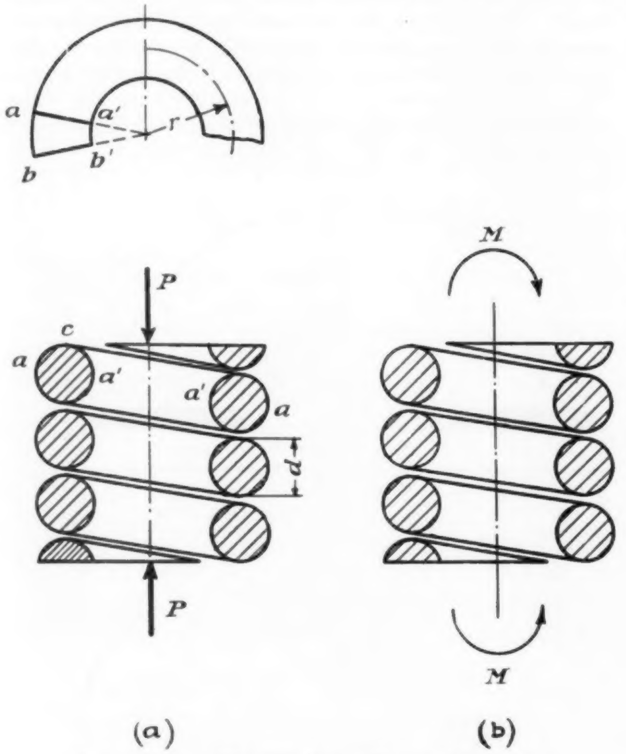


FIG. 1 HEAVY HELICAL SPRING UNDER AXIAL LOAD

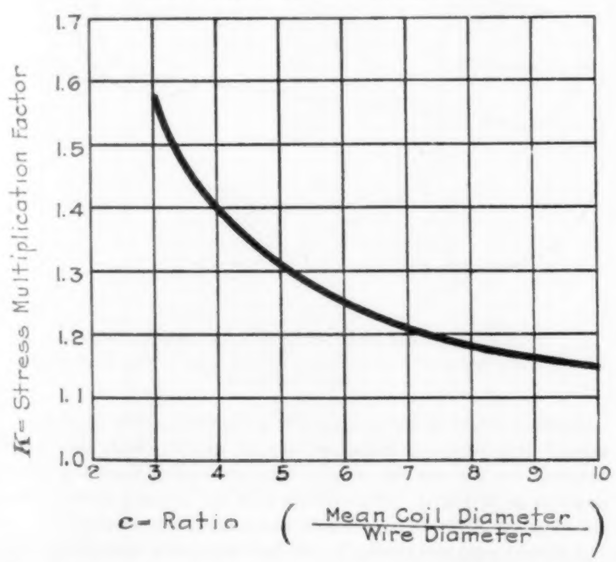


FIG. 2 CURVE FOR DETERMINING THE STRESS MULTIPLICATION FACTOR K

The ordinates of the curve in Fig. 2 give the stress multiplication factor K as a function of the ratio c, plotted as abscissas:

$$K = \frac{4c - 1}{4c - 4} + \frac{0.615}{c} \quad \text{[2]}$$

The value K is thus the factor by which the stress determined by the ordinary spring-design formula or the ordinary spring tables must be multiplied to get the true maximum stress in the spring. It will be seen from Fig. 2 that as c becomes larger the value of K approaches unity and the ordinary formula or tables may be applied with greater accuracy.

A similar analytical expression for the stress on the outside of the coil, i.e., at a [Fig. 1(a)], is:

$$S_{\min} = \frac{16Pr}{\pi d^3}\left(\frac{4c + 1}{4c + 4} - \frac{0.615}{c}\right) \quad \text{[3]}$$

This is again the ordinary spring-design formula multiplied by a factor always less than unity.

A photograph of a typical fracture of a coil of a heavy helical spring is shown in Fig. 3. Equations [1] and [3] applied to the stress at points a' and a of this spring showed that the stress at a' was nearly $2^1/_2$ times that at a. That these springs invariably fail on the inside of the coil near a' is in view of these facts not so surprising.

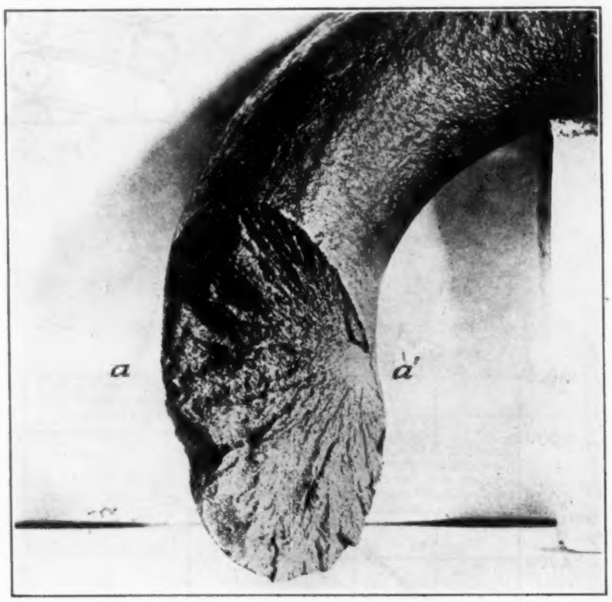


FIG. 3 TYPICAL FRACTURE OF COIL OF A HEAVY HELICAL SPRING

To apply the new formulas to practical cases it is only necessary to take the stress from one of the many published spring tables and multiply this value by the stress multiplication factor K taken from the curve of Fig. 2.

EXPERIMENTAL VERIFICATION OF NEW STRESS FORMULAS

To check up the formulas given by Equations [1] and [3], strain measurements were made on large helical springs of $1^1/_2$-in. diameter wire and having a mean coil diameter of $4^1/_2$ in. A special extensometer was applied as shown in Fig. 4 to the outside of the coil. Since a shearing stress consists of a tension and a compression both at 45 deg. to the axis of shear, the extensometer points were placed at an angle of 45 deg. to the axis of the wire.

The results of the tests on this spring are given in Fig. 5. Here the full line represents the experimentally determined stress on the outside of the coil as a function of the axial load P on the spring. The dotted line which nearly coincides with the test curve represents the stress figured by Equation [3]; the second dotted line represents the stress given by the ordinary spring-

design formula. It will be seen that in this case the ordinary formula is greatly in error. Had it been possible to get on the inside of the spring there is every reason to believe that we should find a stress given by Eq. [1], i.e., a stress 60 per cent greater than that figured by the ordinary design formula.

In order to apply the special extensometer to the inside of the coil and measure the maximum stress in the spring a special set-up was designed as shown in Fig. 6. Two steel pieces were welded on to a semi-coil of an actual helical spring as shown. These two pieces had spherical seats so that axial loads P could

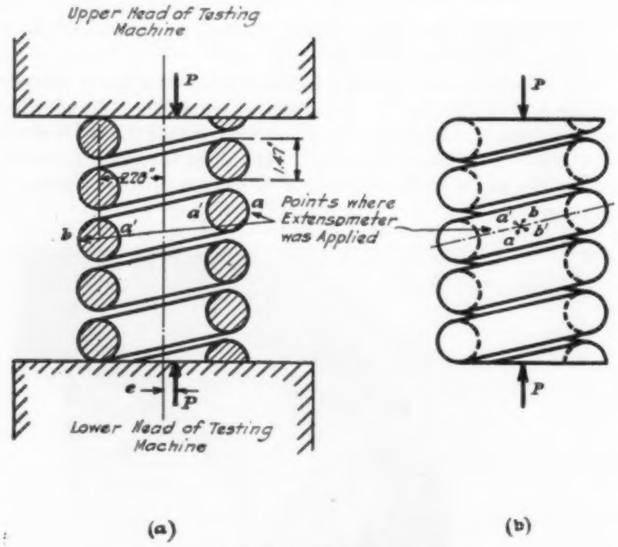


FIG. 4 COMPRESSION TEST OF SPRING

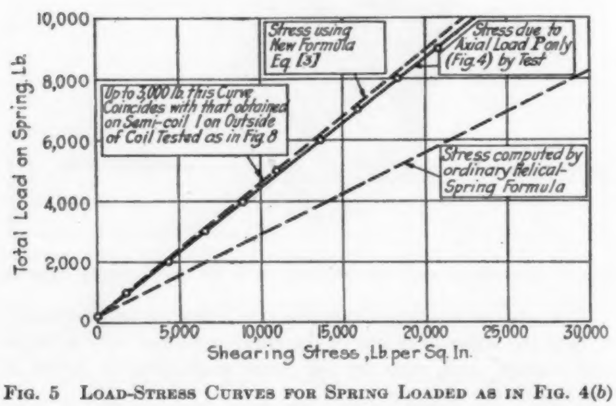


FIG. 5 LOAD-STRESS CURVES FOR SPRING LOADED AS IN FIG. 4(*b*)

be applied by means of a testing machine through the intermediary of an eyebolt having a screw with a rounded end to fit into the spherical seat *c*. In this way an axial load could be applied to the semi-coil and the axial loading of a helical spring in service completely simulated. At the same time it was possible to apply the special extensometer at the point of maximum stress on the inside of the coil. Views of the semi-coil in the testing machine are shown in Figs. 7 and 8, these being views with the extensometer in position for measuring the stress on the outside and inside of the coil, respectively. The points, 1 cm. apart, where the extensometer was applied are shown by *a*, *b* and *a'*, *b'* in Fig. 6.

The results of the tests on these semi-coils are shown in Fig. 9. The ordinates of this curve represent load on the spring and the abscissas, shearing stress. Load-stress curves determined experimentally as described above are shown by full lines for the inside and outside of the coil. The dotted lines which nearly coincide with the full lines represent the theoretical curves for stress on the inside and outside of the coil computed by Equations [1] and [3], respectively. The third dotted line represents the stress computed by the ordinary spring-design formula or tables. It will be seen that the new formulas presented in this paper give results in good agreement with test results, and that the ordinary formula is greatly in error. It should also be noted that, whether determined analytically or by test, the actual shearing stress on the inside of the coil is nearly $2^1/_2$ times that on the outside.

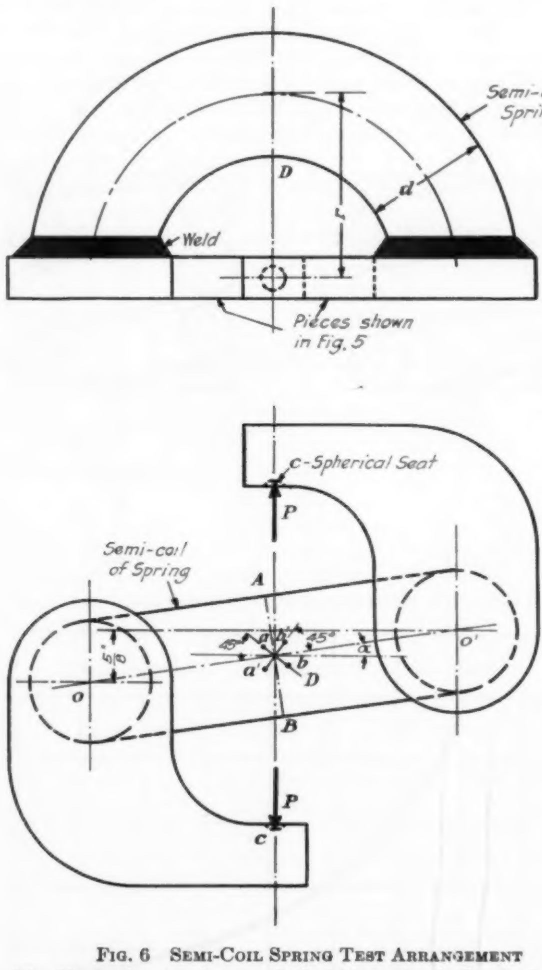


FIG. 6 SEMI-COIL SPRING TEST ARRANGEMENT
(The Fig. 5 referred to in upper half of illustration is Fig. 5 of the unabridged paper.)

Another interesting point to note is that the stress on the outside of this semi-coil coincides almost exactly with the curve obtained on the outside of the complete spring tested in compression as in Fig. 4. This shows that the loading of the semi-coil does simulate the axial loading of a complete spring.

A second semi-coil similar to the first was made and tested with almost identical results, thus giving a further check on the theory.

THE PRACTICAL SIGNIFICANCE OF THE NEW FORMULAS

Let us consider what these new formulas mean in the practical design of springs. Take, for instance, railway passenger-car springs. These are often designed for a working stress in shear of 65,000 lb. per sq. in., using the ordinary spring tables. Since

these springs commonly have a ratio of mean coil diameter to wire diameter of 4, the application of the new formula using the stress multiplication factor of Fig. 2 gives a stress of 90,000 lb. per sq. in. at the working load, an appreciable increase over 65,000 lb. per sq. in. To this stress must be added a vibratory stress of considerable magnitude, which may at times, as when passing over track irregularities when the spring is compressed nearly solid, be sufficient to cause a total resultant stress of the order of 150,000 lb. per sq. in. determined by the more exact formulas.

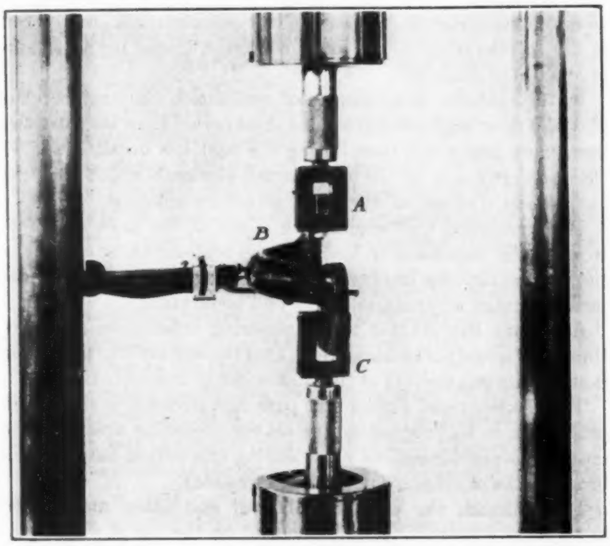


Fig. 7 Semi-Coil Test Arrangement

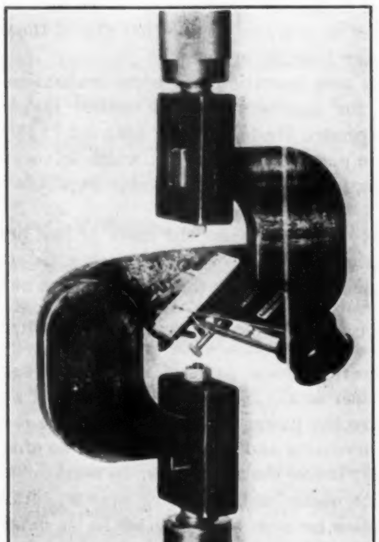


Fig. 8 Test With Extensometer on Inside of Coil

It is therefore not so surprising that frequent failures of these springs occur, especially since the spring material is apt to be decarburized or in other ways inferior at the point on the inside of the coil where these high stresses occur.

Furthermore, the coil diameters of helical springs are often reduced with the idea of reducing the stresses. The formulas brought out in this paper show that there is a limit to the gain which may be possible by this procedure. For example, take the case of a spring where the ratio c of mean coil diameter to wire diameter is 4. By decreasing the coil diameter so that $c = 3$, the twisting moment Pr is reduced about 25 per cent but at the same time the stress multiplication factor k is increased about 15 per cent. Consequently the net reduction in stress is not 25 per cent as would be expected using ordinary spring formulas, but considerably less. At the same time, reducing the diameter has the serious disadvantage of greatly reducing the flexibility of the spring, the flexibility being proportional to the cube of the coil diameter.

Summary and Conclusions

In this paper it has been shown that the true shearing stress in heavy, closely coiled helical springs axially loaded may in many

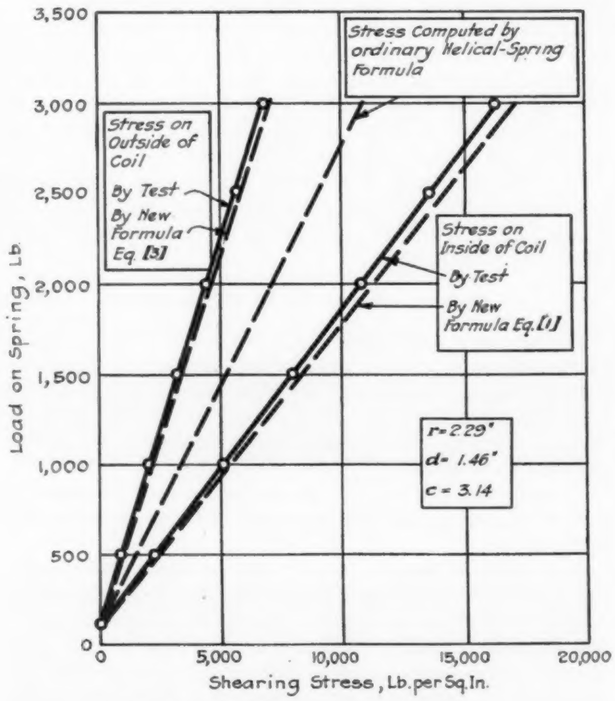


Fig. 9 Load-Stress Curves for Semi-Coil

practical cases be from 40 to 60 per cent greater than that calculated by ordinary helical-spring formulas. Certain more exact formulas have been derived for facilitating the practical calculation of maximum shearing stress in springs of this type. These new formulas have been checked by means of strain measurements on semi-coils of actual springs and on full springs loaded in compression.

It should be noted that the new formula herein given applies not only to the calculation of heavy springs having a small ratio c of mean coil diameter to wire diameter, but also to light springs where the value of c is large. In any case the new formula applies with greater accuracy than the ordinary helical-spring formula; however, where the ratio of diameters c is greater than 6, the ordinary formula is accurate within 25 per cent as may be seen by reference to the curve of Fig. 2.

Since these new formulas have been thus shown to be correct, it is the author's opinion that they should be applied in the practical design of helical springs of this type. It is also the author's belief that the frequent failures of heavy helical springs may at least in part be explained by the existence of much greater stresses than thought possible, on the basis of ordinary spring theory.

The Engineer

By JOHN HAYS HAMMOND,[1] WASHINGTON, D. C.

NOT long ago in discussing the unemployment situation at that time somewhat serious, with a politician friend of mine, of the alarmist type, he said: "You engineers are in a large measure responsible for unemployment, in that by the invention of labor-saving devices men have lost their jobs."

I replied that this plaint reminded me of that of the chairman who a few years ago here in Washington presided at a meeting of the Association of Tombstone Makers. The chairman stated, in a reproachful spirit, that the tombstone business was in a deplorable condition owing to the increased longevity of the people.

I further stated that as a matter of fact while the introduction of labor-saving machinery has cost a good many men their jobs in certain industries, nevertheless there has been an expansion of industrial operations in other fields of activity owing to economies effected by labor-saving devices which more than compensated for the unemployment to which he referred.

This is a gathering of American engineers in honor of our esteemed guest of honor the Japanese Ambassador, and for that reason I trust the tribute I shall pay to the engineering profession will not be inappropriate.

Engineering an Ancient Profession

Engineering is a profession so old that it has never been traced to its beginnings. When we get back to the misty boundary between the earliest accurate historical records and that vague time which we know as "pre-history," we find extraordinary monuments to the genius of engineering which have already been standing for centuries.

Nevertheless, until recently the engineer did not command the influential position he now deservedly holds in the estimation of the public.

In progressive America, for example, the engineer who was engaged in the development of the resources of the so-called backward countries—backward in respect of their economic position—was stigmatized by our politicians as an advance agent of unprincipled exploiters of those countries. Today, however, he is recognized as a most important missionary of civilization in opening up new territory to contribute its mineral wealth and, incidentally, its other resources to the needs of mankind.

The engineer is now universally regarded not only as a benefactor of the world at large, but as a primary factor in the betterment of conditions of the inhabitants of those countries developed by his professional skill, his indomitable courage—for courage is requisite in pioneering—and his indefatigable industry.

The engineer will, I believe, become a real "Ambassador of Good-Will" when the slow-consenting academic mind realizes, as it must, that beneficent deeds are more enduring and more convincing than mere gestures of professed amity.

It was the World War that established the engineer as the most important of the factors of modern civilization. Owing to the overweening ambition of so-called statesmen, the war was made possible. Inept diplomacy failed to avert it.

The engineer whose life work is devoted to the creation of material prosperity and the resulting social welfare is preeminently an "Apostle of Peace."

Wanton destruction is to him for that reason anathema, but when the World War began it was upon the skill of the engineer that the warring nations relied for their national defense—indeed, for their very existence.

Then came peace, after the most devastating war of all time, and a stricken and bewildered world—victors, vanquished, and neutrals alike—sought the services of the engineer during the work of reconstruction, not only in its economic rehabilitation but in the amelioration of the social condition of the destitute survivors of the cataclysm.

In the material development of civilization the engineer has played a most important role, and in no period have his activities been more important than during the past few decades. If we eliminate any one of the engineering elements which underlie our present civilization, the entire structure collapses.

The realization that engineering is one of the most dignified, most vitally important to life of all the professions, and that the work of engineering has been the expression of one of the fundamental human instincts, is a very real inspiration.

After one has studied the engineering achievements of antiquity, it seems paradoxical to say that the engineering profession is still in its infancy. Yet this statement is undoubtedly true.

The development during the past few decades is out of all proportion to its progress during all the preceding ages, and the discoveries and inventions made during this period have opened broad vistas of infinite length in all directions.

The railroad, the wide use of steel and other metals, the methods of construction which depend on the use of steam machinery, the use of electricity for light, heat, power, and communication, the internal-combustion engine, the submarine, the airplane and radio, are products of a century of unparalleled activity. Yet no one can assume that any of these has attained perfection—far from it, indeed.

With each new invention has come realization of unlimited possibilities for improvement and endless ramifications. The telegraph suggested the telephone; both led to the wireless; the balloon made possible the dirigible, which in turn suggested the heavier-than-air machine, made feasible by the invention of the gas engine.

Nothing is more false than the more or less prevailing belief that imagination is useful only to the poet, artist, or philosopher, and should be suppressed by the practical man as dangerous.

The Engineer, Though Practical, Must Be a Dreamer

The engineer, practical as he is, must at the same time be as much a dreamer as any of these if his work is of any magnitude. He must have the power to see a thing before it exists. In all his work of inventing and planning he must be able to see a need and its remedy before the need arises; he must forestall difficulties and overcome obstacles before they appear. At each stage of the construction he must be able to see in his mind's eye exactly how the work will look in the future.

In our country it has only recently been recognized that the qualities that make an engineer of outstanding reputation are those peculiarly suited to the administration of governmental affairs.

Few remember that the first President of the United States George Washington, was by training a civil engineer. All now recognize that his education and experience as an engineer are the qualifications that peculiarly commend our present President, Herbert Hoover, to the confidence of the American people in the

(Continued on page 447)

[1] Past-President, A.I.M.E.; Mem. A.S.M.E.

Address delivered at a dinner given at the Carlton Hotel, Washington, D. C., April 24, 1929, in honor of the Japanese Ambassador.

Effect of Design and Operating Conditions on Condenser-Tube Deterioration

Progress Report No. 2 of the A.S.M.E. Special Research Committee on Condenser Tubes,[1] Comprising the 1928 Report of Its Sub-Committee on Questionnaire[2]

At THE December, 1927, Meeting of the A.S.M.E., following the presentation of the Report of the Sub-Committee on Questionnaire of the Special Research Committee on Condenser Tubes, it was suggested that factors other than bad water, tube material, and manufacture might be the cause of rapid condenser-tube deterioration.

The belief was expressed that in addition to bad water, entrained air and turbulent water conditions within the water boxes and tubes affect the kind and degree of condenser-tube deterioration. Accordingly the Sub-Committee was instructed to obtain data relative to these conditions.

The Sub-Committee believes that, where the condenser-tube failure is caused by corrosion, erosion, impingement attack, or pitting, turbulence and entrained air aggravate the condition and may even be the cause thereof.

In considering corrosion there is perhaps no doubt that certain elements contained in the circulating water produce this form of failure, but the rapidity of deterioration therefrom may be greatly increased by the presence of air. That this may be the case will be illustrated by an example. Consider water devoid of air entering and passing through a condenser tube free from internal obstruction. Whatever turbulence there is at entrance will likely cease within a short distance of travel. The flow will then be smooth, with water in contact with the tube wall at all points. The heat-transfer rate and temperature will remain practically constant, and the action of corroding elements in the circulating water will continue at a fairly uniform rate. Now consider the case where the circulating water contains entrained air. As the air is released from the water it naturally tends to crowd the inner wall of the tube, and in doing this momentarily reduces the heat transfer and increases the temperature at the point of contact. Thus the rate of action of the corroding elements in the circulating water is increased. This condition becomes worse as the inner surface of the tube becomes less smooth and further retards the free flow of the air bubbles and increases the rate of corrosion.

Erosion is considered because corrosion generally accompanies it with the same destructive action as outlined above, excepting that the corroded part of the tube is carried away by the action of the abrasive substances in the circulating water. A typical example of this is shown in Fig. 1.

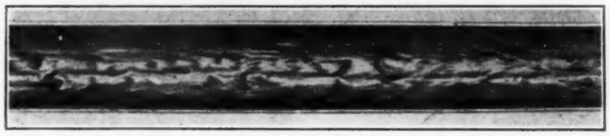


Fig. 1 Showing Erosion of Corroded Tube

Fig. 2 Impingement Attack

Impingement attack and pitting are very similar, the former appearing only in the inlet ends of the condenser tubes as indicated in Fig. 2, while the latter may occur at any point in the tube. The action that takes place may be somewhat as follows: The turbulent condition of the entering water or the release of the entrained air anywhere along the tube causes bubbles of air to be caught between the slow-moving, viscous water film on the tube wall and the faster-moving strata within the tube. Due to this difference in velocity the bubble loses its spherical form, becoming elongated and flattened in the form of a thin film of air. This film finally breaks, causing myriads of small bubbles to become instantly spherical, and permits the faster-moving inner strata of the water to impinge upon the slow-moving outer strata with some violence. This continued bombardment on the

[1] The personnel of this Committee is as follows:
Albert E. White, Chairman, Director, Department of Engineering Research, University of Michigan, Ann Arbor, Mich.
Paul A. Bancel, Manager, Condenser Department, Ingersoll-Rand Company, New York, N. Y.
R. H. Barber, New Bedford Gas & Edison Light Co., New Bedford, Mass.
Wm. H. Bassett, Technical Supt., The American Brass Company, Waterbury, Conn.
George G. Bell, Manager, Power Development, West Penn Power Co., Pittsburgh, Pa.
Donald K. Crampton, Metallurgist, Chase Metal Works, Waterbury, Conn.
Harvey M. Cushing, Chief Engineer, Buffalo General Elec. & Gas Co., Buffalo, N. Y.
Harold F. Eddy, Mechanical Engineer, Commonwealth Power Corp., Jackson, Mich.
H. B. Hird, Bureau of Engineering, Navy Department, Washington, D. C.
Vincent M. Frost, Asst. to General Supt. of Generation, Public Service Electric and Gas Company, Newark, N. J.
Walter L. Green, Jr., Superintending Engineer, Luckenbach Steamship Co., Inc., Brooklyn, N. Y.
Charles F. Harwood, Manager, Condenser Dept., Worthington Pump & Machinery Corp., New York, N. Y.
Clarence F. Hirshfeld, Chief, Research Dept., Detroit Edison Co., Detroit, Mich.
Bert Houghton,[2] Chairman of Sub-Committee on Questionnaire, Operating Supt., Brooklyn Edison Co., Inc., Brooklyn, N. Y.
Howard W. Leitch, General Supt. of Power Plants, The United Electric Light & Power Co., New York, N. Y.
D. W. R. Morgan,[2] Mgr., Condenser & Internal Combustion Engrg., Westinghouse Electric & Manufacturing Co., South Philadelphia, Pa.
Wm. B. Price, Chief Chemist, Scovill Manufacturing Co., Waterbury, Conn.
Norman G. Reinicker, Superintendent of Operation, Penn Power & Light Company, Allentown, Pa.
Horace A. Staples,[2] Vice-President, British American Metals Company, Inc., Plainfield, N. J.
William R. Webster, Vice-President, Bridgeport Brass Company, Bridgeport, Conn.

[2] Sub-Committee on questionnaire: Messrs. Bert Houghton (Chairman), D. W. R. Morgan, and Horace A. Staples.

Presented at the Annual Meeting of the A.S.M.E., New York, December 5, 1928.

tube wall causes minute pits or pinholes to appear, which become deeper and deeper as time goes on and ultimately puncture the tube. Where corrosive elements are contained in the circulating water or where an electrochemical action takes place, the rate of deterioration is greatly increased and the appearance of the pits will be jagged and rough as shown in Fig. 3; whereas in those cases where there is no corrosive or electrochemical action, the pits will appear as smooth, round holes.

Looking over the situation the Sub-Committee immediately recognized the improbability of acquiring directly the information sought, due to the inability to visualize the water as it enters the condenser water boxes and tubes and the difficulty in obtaining accurate information on the amount of entrained air in the circulating water. Hence it was decided to draw up a questionnaire designed to obtain information which would throw light on the flow of circulating water from the intake tunnel to the discharge of the condenser.

By obtaining information on certain design features of the condenser installations in various plants, comparing these, and noting the type and rapidity of deterioration of the tubes, it was

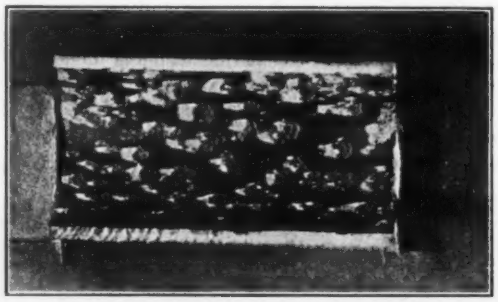


Fig. 3 Rough, Jagged Pitting Produced When Corrosive Elements Are Contained in the Circulating Water

expected that conclusions relative to the extent of turbulence and entrained air within the water boxes and tubes of the condenser could be determined.

It was expected that the data on water-box design, piping arrangement, pump design, and pump speed would give a reliable indication of the condition of the water entering the condenser tubes. It was contended that installations in which the water was least agitated would contain the least amount of entrained air, have less turbulence, and cause fewer condenser-tube failures.

In addition specific questions regarding the amount of entrained air, kind of circulating water, service hours of the condenser, type of tube failure, the number of tube failures, and other pertinent matters were incorporated in the questionnaire. For comparative purposes it was requested that each company submit data on two installations: one in which the greatest number of tube failures occurred, and the other, the least.

The experience of the Sub-Committee in obtaining data for last year's report indicated the desirability of having some standard notation for the various types of condenser-tube failures. Hence the Sub-Committee formulated a tentative standard for designating condenser-tube failures, and attached a copy to each questionnaire.

The questionnaire was sent to forty representative companies, covering sections of the country where both salt and fresh water are used for circulating purposes.

Thirty-three companies replied to the questionnaire, submitting varying amounts of detailed information on design and operation. Because of this lack of completeness of detailed information and due to the various methods of retubing and operation and differences in circulating-water analysis, it is

TABLE 1 SELECTED DATA FROM REPLIES TO A.S.M.E. CONDENSER TUBE RESEARCH COMMITTEE'S QUESTIONNAIRE

(A—Greatest number of failures; B—least number of failures)

	Number of Company Reporting															
	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)	
	A	B	A[2]	B	A	B	A	B	A[3]	B[3]	A	B	A	B	A	B
Condenser size, sq. ft.	20,000	20,000	50,000	50,000	40,000	32,000	25,000	32,000	75,000	55,000	50,000	50,000	40,000	50,000	15,000	12,000
Number of passes	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Ratio of pump capacity to water-box volume:																
Inlet end	29.7	21.1	30.5	30.5	34.7	31.2	41.3	21.5			33.2	41.7	37.3	23.4	40.8	35.6
Receiving box	17.5	16.4	15.2	15.2	15.0	10.1	38.0	10.6	40.1	33.9	19.3	20.8	34.1	20.4	29.3	26.7
Outlet end	29.7	21.1	30.5	30.5	34.7	25.9	50.5	21.5			33.2	41.7	38.0	22.0	40.8	35.6
Material of tubes	Adm.	Adm.	Adm.	Adm.	Adm.	Adm.	Adm.	Adm.	Adm.	Adm.	Adm.	Adm.	Adm.	Adm.	Copper	Copper
Spacing of tubes on centers, in.	2	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 15/16–1 5/8	1 4/16–1 5/8	1 3/8	1 3/8	1 1/2	1 1/2	1 5/8	1 5/8
Slope of tubes, in. per ft.	....	....	0	0	Slight	Slight	0	0	0.05	0.05	0.08	0.08	0.14	0.15	0	0
Material of ferrules	Adm.	Adm.	Adm.	Adm.	Brass	Brass	...	...	Adm.	....	Brass	Brass	Brass	Brass	Muntz	Muntz
Projection into water box, in.	11/16	3/8	3/4	3	15/32	15/32	3/8	3/8	....	....	7/16	7/16	3/8–1/2	1/2	7/16	5/16
Number of circulating pumps	1	1	2	2	2	1	1	1	2	2	2	2	2	1	1	1
Circulating-pump capacity, gal. per min.	30,000	30,000	30,000	30,000	30,000	25,000	34,000	45,000	60,000	37,000	35,000	36,000	30,000	70,000	18,000	20,000
Circulating-pump speed, r.p.m.	380	455	500	500	435	450	290	470	290	290	348	295	455	284	450	400
Area of pump inlet, sq. ft.	7.1	8.7	9.6	7.1	7.1	7.1	9.3	19.6	19.6	14.7	15.9	15.9	19.6	7.7	3.7	4.9
Area of pump discharge, sq. ft.	6.3	8.5	7.1	7.1	4.9	4.9	8.3	6.5	14.7	10.1	9.6	9.6	8.5	15.9	3.1	3.1
Impeller diameter, in.	32	28	31 7/8	31 7/8	26 1/2	25 1/2	36	34	.....	38	36	39	....	40	22 3/4	27
Angular change in circulating water flow from pump discharge to tube flow, deg.	330	240	180	180	360	255	270	270	180	180	210	205	180	180	315	180
Velocity of water at pump inlet, ft. per sec.	9.5	7.7	6.9	6.9	6.3	7.9	8.1	5.1	6.8	5.6	4.9	5	3.4	8.8	11	9
Velocity of water at pump discharge, ft. per sec.	10.7	7.9	9.5	9.5	9.0	11.4	9.1	15.4	9.1	8.3	8.1	8.4	7.8	9.8	13	14
Impeller-tip speed, ft. per sec.	53.1	55.6	69.5	69.5	50.3	50.1	45.6	69.7	....	48.1	54.7	50.2	...	49.6	44.7	47.1
Ratio of impeller-tip speed to discharge velocity	5.0	7.0	7.3	7.3	5.6	4.4	5.1	4.5	....	5.8	6.8	6.0	...	5.1	3.43	3.36
Type of failure[1]	II–V–VI	II–III	III–VI	III–VI	III–VI	III–VI	II–III	...	III–VII	III–VI	V	V	I–III	I–III	V–VI	V–VI
Location (top or bottom of tube)	Both	Both	Bottom	Bottom	Top and side	Top and side	Both	...	Bottom	Bottom	Both	Both	Both	Both	Both	Both
First pass	Inlet	Gen.	Inlet	Inlet	Inlet	Inlet	Inlet	...	Gen.	Inlet	Inlet	Inlet	Inlet	Inlet	....	Gen.
Second pass	....	Gen.	Inlet	...	...	...	...	...	Gen.	....	Inlet	Inlet	Inlet	Inlet	Gen.	...
Kind of circulating water	Salt	Salt	Salt	Salt	Salt	Salt	Salt	Salt	Salt	Salt	Salt	Salt	Salt	Salt	Fresh	Fresh
Rate of tube failure: tubes per service hour	0.178	0.023	0.003	0.0025	0.012	0.002	0.224	...	0.003	0.001	0.266	0.234	0.459	0.425	0.209	0.002
Per cent of condenser surface failed per 1000 service hours	6.11	0.47	0.031	0.027	0.16	0.04	4.0	...	0.21	0.12	2.68	2.42	6.73	4.2	6.59	0.06

[1] See "Nomenclature for Designating Types of Condenser-Tube Failure." [2] Wearing tips installed. [3] Electrolytic protective system.

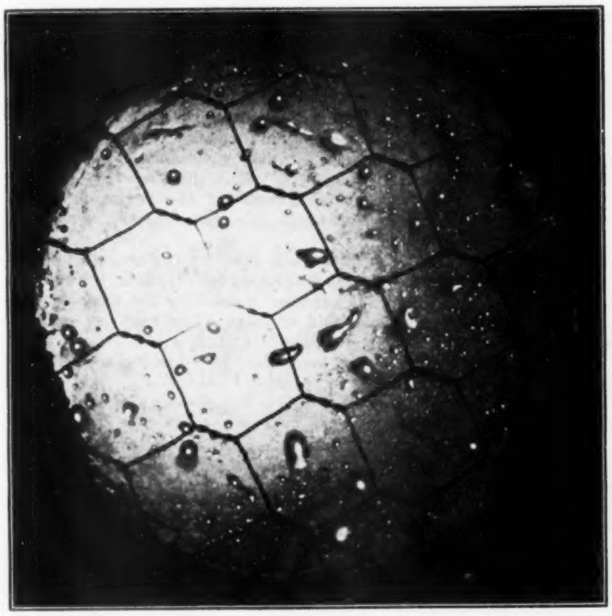


Fig. 4

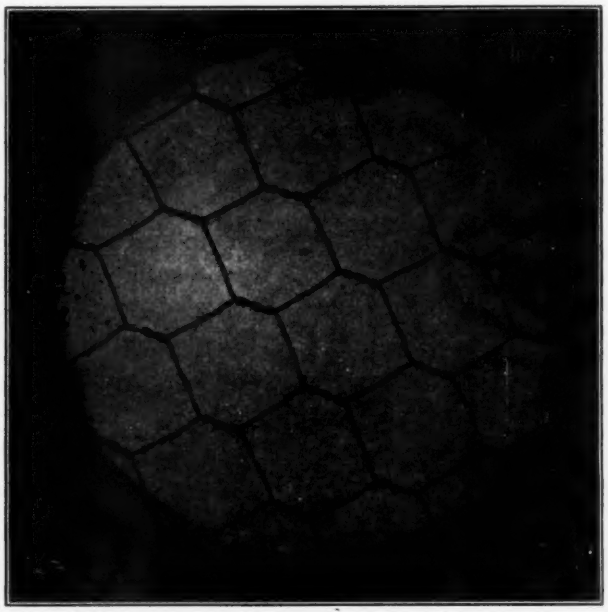


Fig. 5

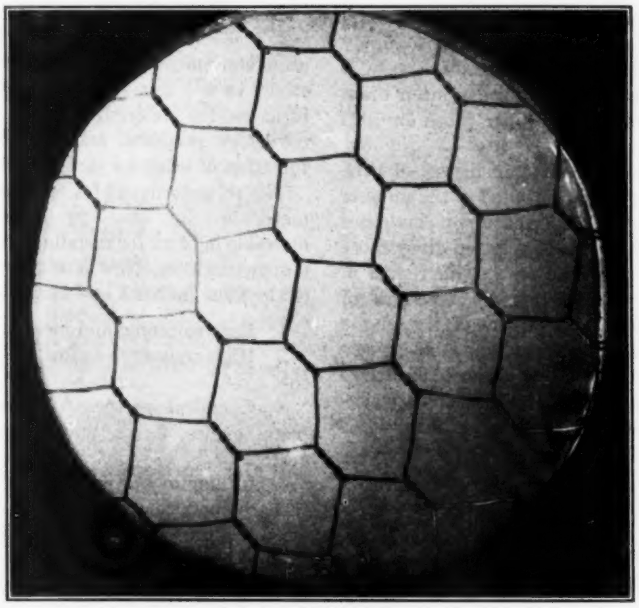


Fig. 6

FIGS. 4–6 APPEARANCE OF WATER IN WATER BOX OF CONDENSER AT TIME OF STARTING PUMP (FIG. 4) AND AFTER PUMP SPEED HAS BEEN INCREASED (FIGS. 5 AND 6)

extremely difficult to make accurate comparisons. However, a study of the data seems to indicate that there may be factors other than bad water and tube material tending to deteriorate condenser tubes rapidly.

Design comparisons of the data as a whole neither bear out nor refute the above contention. A number of companies report their greatest failures where design conditions apparently cause the least agitation, while about an equal number report that the reverse is true. Such comparison, however, does not take into account factors other than design, and is therefore misleading.

To eliminate, in the same station, the effect of any radical difference in condenser design, dissimilarity in tube material, and variation of circulating-water analysis, Table 1 has been prepared. As corrosion, erosion, impingement attack, and pitting of the condenser tubes are the main types of failure believed to be affected by turbulence and entrained air, only the eight plants reporting any of these types of failure are considered in the table.

In this table the ratio of the circulating-water pump capacity at full load to the water-box volume and the ratio of impeller-tip speed to the discharge velocity have been computed. These figures in conjunction with the angular change in direction of the circulating-water flow from the pump discharge to the direction of the condenser-tube flow should give a fairly reliable indication of the condition of the circulating water within the water boxes and condenser tubes.

The first of these is rather interesting as it is not only a capacity ratio but also indicates directly the number of times per minute each water box is filled and emptied. Referring to the table, it will be noted that in all but two of the installations this ratio is greater in the "A" column (representing the condenser having the greatest number of tube failures) than in the "B" column.

The ratio of the impeller-tip speed to the discharge velocity is, in all but one case, equal or greater in the "A" column than in the "B" column. The data on impeller clearances were so meager that no attempt is made to draw conclusions therefrom.

It is also apparent that those installations where the design of the circulating-water piping causes the water flow to have a greater angular change in passing from the pump discharge to the direction of flow through the tubes, also have the greatest number of tube failures. This is in line with the Sub-Committee's belief regarding turbulence and entrained air; that is, the higher ratios will have the greater agitation, and therefore be more turbulent and contain more entrained air.

Several companies have made studies of the condition of the water within the water box of the condenser. These were made by installing a glass door in the head of the condenser, placing a

large light in the water box, and observing the character of the water as it passes through the water box. All report the presence of a considerable amount of air in the form of large and small bubbles. However, it was impossible to observe the action of the water entering the tubes as the depth of vision was limited. Fig. 4 shows the condition of the water immediately after the circulating pump was started. Figs. 5 and 6 show the milky appearance of the water after the pump speed had increased.

A number of the companies report tube failure at the inlet end of the first pass due to pitting, impingement attack, and erosion, and it is quite possible that these failures are caused by the turbulent condition of the circulating water as it enters the tubes. This conclusion is borne out by the replies of companies that have installed wearing tips in order to obtain a less turbulent entrance flow and to reduce the vena contracta effect. The projection of ferrules and wearing tips into the water box has also been increased with the same object in view.

That entrained air may be a factor in the deterioration of condenser tubes by pitting is supported by the replies of several companies which report that the greatest number of failures occur in the second pass. The Sub-Committee believes that this pitting is caused by the release of the entrained air as the circulating water increases in temperature, and is probably aggravated by the turbulence caused by the return bend of the circulating water in passing from the first to the second pass.

As to tube material, Admiralty Mixture is used practically exclusively in plants where salt water is employed for circulating purposes, and many of the fresh-water installations also employ this metal. One exception to this and an interesting case is found in a salt-water plant where for the best condition brass tubes are used. Muntz-metal and a few copper tubes are also evident in the fresh-water localities.

The data indicate a rather wide variation in degree of tube deterioration. Tube failures have been computed in the number of tubes failed per service hour, and in the percentage of condenser surface failed per 1000 service hours. The latter gives more accurate figures for comparative purposes as the differences in condenser size are eliminated. The average percentages of condenser surface failed per 1000 service hours of the plants reporting tabulated at the head of the next column.

One of the peculiarities noted is that the pump discharge velocities in the salt-water plants are higher for their best conditions, while the reverse is true for the fresh-water plants.

		Per cent per 1000 service hours
Average best condition	Salt water	1.035
Average worst condition	Salt water	3.148
Average best condition	Fresh water	0.198
Average worst condition	Fresh water	1.347

In summarizing from the data submitted it is quite evident that factors other than bad water and tube material and manufacture are responsible for the deterioration of condenser tubes. This is clearly shown by the difference in tube deterioration between condensers in the same plant where the circulating water and tube material are similar.

The Sub-Committee attributes this difference to the entrained air in, and turbulent condition of, the circulating water, and the data submitted substantiate this.

NOMENCLATURE FOR DESIGNATING TYPES OF CONDENSER-TUBE FAILURE

I *General Thinning or General Corrosion.* The wasting away or thinning down of the tube. The inside surface of the tubes is evenly corroded without the formation of pits or dezincified spots. Little or no basic salt on the tube.

II *General Dezincification.* The tube is generally not thinned down to any considerable extent. The zinc is taken out, leaving a mass of spongy and more or less brittle copper behind. This shows when broken a red or brick-like fracture extending from the inside partly or completely through the tube wall. It is frequently more or less irregular, so that the tube wall is completely dezincified in places and on other places not entirely so.

III *Deposit Attack or Pitting.* Small, round pits or pinholes beneath green salt and cuprite. Foreign deposits often accompany this type of corrosion. When these pits or pinholes contain plugs of copper, this is known as "plug type" dezincification.

IV *Tailed-Type Pitting.* Pits formed by the removal of the scale and having a deep section at the upstream side and a shallow tail at the downstream side.

V *True Erosion.* The tube is worn away by the action of solids in the circulating water, often accompanied by corrosion.

VI *Impingement Attack.* Corrosion caused by air bubbles and generally confined to the inlet end of tube. This may be uniform thinning or it may appear as grooving.

VII *Scale Thinning.* Scale kept thin by chemical action, resulting in corrosion and in isolated pits.

VIII *Solution.* Scale absence due to the presence of acids, etc., resulting in general thinning.

IX *Splitting and Season Cracking.* Splitting in a longitudinal plane caused by internal strain in the tube metal or undetected defects within the tube walls. Season cracking may be due to the same cause as splitting, and in addition may be due to stresses set up in expanding and rolling the tube ends in the tube sheets.

A Modern Refractories Laboratory

THE Baltimore laboratory of the General Refractories Co. may be considered as a typical example of a modern research laboratory in the refractory field. In addition to the usual equipment there is a special enclosed room for petrographic study, as well as a spalling and a reheating furnace, two distinct furnaces for determining the pyrometric-cone equivalent of refractory products, and a special furnace for studying disintegration of brick by carbon monoxide.

The refractoriness of a brick is determined largely by the raw materials. But many properties other than refractoriness are desirable in brick for metallurgical service. William F. Boericke, mining engineer, New York, has given the essential properties of the ideal firebrick as follows:

1 High softening and melting points under normal load.

2 High resistance against sudden sharp changes of temperature.

3 Chemical inertness when confronted with the influence of metal oxides, fluxes, and products of combustion that cause corrosion.

4 Minimum possible change of shape and volume under all furnace conditions.

5 High resistance to mechanical stresses and shocks, in both the hot and cold state.

6 Uniform composition, so that a buyer may be sure at all times of receiving the identical product.

In an attempt to secure these properties much research work has been done in developing new raw materials for brick manufacture. Chrome brick has a bond at high temperature determined largely by the character of the accessory minerals in the ore. Before the research laboratory took up the study of this property, it was not generally understood why some bricks were strong in this respect and others poor when the process of manufacturing was the same. Petrographic studies have pointed out which impurities in the ore affected the bond, and now by proper blending it is possible to produce a uniformly strong bond in brick embodying the high refractoriness of chrome ore. Much the same study and progress has taken place in the manufacture of magnesite brick. (H. R. Simonds, Associate Editor of *Iron Trade Review*, in *Iron Trade Review*, vol. 84, no. 16, Apr. 18, 1929, pp. 1049–1051.)

The Organization of Scientific Research in Industry

The two brief but cogent papers which follow are contributions by men eminent in the industrial-research field to a symposium which formed part of the program of Section M (Engineering) at the Fifth New York Meeting of the American Association for the Advancement of Science, December 27, 1928, to January 2, 1929.

Encouraging Competent Men to Continue in Research

By WILLIS R. WHITNEY,[1] SCHENECTADY, N. Y.

MAN has been researching for at least two hundred thousand years, but only within the last two decades has he heard about organized industrial research. It is therefore fair to say that relatively little is known about the best way of doing it. It is a started experiment, and perhaps people will decide sometime that the present course is a terribly dangerous race for merely material things and so must be changed. We may sometime settle back in static and dynamic equilibrium, each one busied with his neighbor's laundry. But before this is done, we here expect that competent research men will in general receive pecuniary rewards approaching those of men who merely "sell the stuff." There is a healthy tendency in that direction. But this talk is not an appeal to the public for higher salaries, but rather an attempt among ourselves for better understanding of what constitutes encouragement.

Industrial Research an Expression of the Advanced and Advancing State of American Minds

Industrial research is an expression of the advanced and advancing state of American minds. This is true not only of the industries, but of the research men themselves. Nothing seems established except this forward movement. It is what Kettering, of General Motors, might call a "perfectly satisfactory unsatisfied but not dissatisfied state."

The obvious way to encourage is by encouragement, but encouragement has never been standardized. Coin is a token and performs useful functions, and salaries of research men will continue to rise. The accumulated research of an inventor's lifetime used to be sold for what it would bring under a forced sale. Novel processes and new ideas were produced by millions (there are nearly two million American patents), but not one per cent of the hard-working inventors were ever rewarded at all. They worked under heartbreaking disadvantages and carried the entire risk of their ventures. The public would have been well justified in sharing the risk with competent workers. Later it seemed more promising to grubstake the inventor, and this was quite generally done. Many lines of industry were built about a single experimenter. The more recent scheme is to stake groups of trained and selected investigators and combine their work so that new results may be continuous. This is now a tested development. It is easy to see its advantages. On the whole, it costs the public less and produces better results than the shiftless way of rewarding the occasional inventor who ripened his product on the day the market was exactly ready, while declining even to feed the poor fellow who was far-seeing and got ahead of the procession.

[1] Director, Research Laboratory, General Electric Company.

Adequate Compensation Must Include Tokens of Appreciation

But the unlimited use of coin alone does not guarantee satisfaction anywhere, and we are thus led from the subject of salary, in which no one is expert, to the conclusion that the adequate compensation for encouragement to continue research must include those tokens of appreciation which other creative people generally desire. The public they serve should know of the service. This is a strong survival principle for a race. Publication in some form to bring recognition by one's peers is the nearest equivalent to the artistic painting, the beautiful poem, the enduring sculpture, and the splendid architecture of other creators. The most altruistic and far-seeing leaders realize the importance of this encouragement, and even those who have never analyzed it instinctively feel its value.

Another token of research appreciation, strange as it may seem, is further opportunity for more and better work. The research man must progress. In the industry this means improved facilities, new apparatus, and enlarged activity of all kinds. Every good research man wants to work with new and improved tools, and this includes everything, from freedom from interruption to added assistants and floor space. If this encouragement is criticized as not being a token of appreciation, I can only say that it is a weighty matter of experience.

Finding and Encouragement of Competent Men

By F. B. JEWETT,[2] NEW YORK, N. Y.

TWENTY-FIVE years of doing, finding, and encouraging others to do scientific research in industry, and of organizing the machinery for the smooth and effective conduct of such research, have left me with a feeling that so far as this branch of human activity is concerned the problems in essence are not materially different from those met elsewhere. Years ago, in a less mature period of life, I may have thought that the effective industrial-research man was a being somewhat different from his fellow-workers in adjacent fields. I may have thought that some peculiar slant of mind, some slightly different outlook on life, or some special appraisement of relative values branded him with a distinguishing hallmark that designated him unescapably for special treatment and special relationship in the industrial environment.

If such ideas were ever mine, I have long since outgrown them. My present view is that except in those details which are the direct consequence of a particular function, the problem of finding and encouraging competent men in industrial research is in no substantial measure different from the finding and encouragement of competent men in any walk of life. If this conclusion is correct, the subject I have been asked to discuss narrows itself down to a consideration of the things which distinguish achievement in industrial research from achievement elsewhere.

In any discussion of this sort one must have clearly in mind at the outset that which we wish to consider. I take it that

[2] Vice-President, American Telephone and Telegraph Company, and President, Bell Telephone Laboratories.

we are not here concerned with the finding and encouragement of the rank and file of those who do a fair day's work for a fair day's pay in the field of industrial research, nor even with those who do somewhat more than a fair day's work for a fair day's pay. I take it that we are considering what the title of the subject implies, namely, the finding and encouragement of competent men, that is, men competent in a creative sense or competent in those characteristics of administrative ability which make them fit leaders of industrial-research groups or organizations. It is to these men, relatively few in number, to whom we must look for those substantial results which in the last analysis will be the justification for industrial research as we have come to understand it. Without them the term "industrial research" is merely the designation of a shallow thing of little present and no prospective worth.

Rank and File of Modern Research Organization Relatively Easy to Find

The rank and file of the modern industrial-research organization are relatively easy to find, though sometimes difficult to get in sufficient numbers. Mistakes in choosing them are not particularly serious to the organization, however unfortunate they may be for the misplaced individual who persists too long in the wrong environment. The reason for this is obvious from the fact that, taken by and large, the work of the rank and file is at best necessarily a work of detail done under guidance of the more experienced. In this respect the situation of the rank and file in an industrial-research organization is not different from that of the rank and file in any other group activity, whether concerned with industry, the university, or the church.

This does not mean, however, that we are not all anxious to have the best possible material obtainable in the rank and file, or that we are indifferent to the utmost of encouragement and stimulation to its individual members. We want to see each and every one make the most that he or she can out of life. We rejoice at every individual advancement, even though at times that advancement takes the individual out of the organization of which he has hitherto been a part.

Coming now to the finding and encouragement of the group we have designated as "competent," what are the conditions that confront us? In some respects these conditions are easier than those surrounding other activities because they are concerned with narrower fields in which to search. In other respects they are more difficult because of the very narrowness of the field of choice.

I take it for granted that a man is essentially miscast and essentially a transient if he finds himself in a field of endeavor where the primary requisite for success is alien to the thing he most desires. Even if this desire is unrecognized by him at the start, it will sooner or later develop and either wean him away from his environment or leave him a dissatisfied and essentially unproductive member of a fraternity with which he is out of tune.

Put concretely, what I have in mind is that a man driven, let us say, by a zest for personal wealth and the things which personal wealth will buy, is essentially miscast if he embarks in a field which does not lead pretty directly to individual personal wealth. The occasional case of a man capable of turning the opportunities of an otherwise unpromising occupation to the advantage of an aspiration which would normally find its easiest accomplishment elsewhere is no refutation, I think, of this thesis. Wealth resulting directly or indirectly from one's work, on the other hand, may be and frequently is quite different from the desire to accumulate an individual fortune.

Or, take the case of the man whose greatest satisfaction is tied up with his desire to exercise power over his kind. He is in unhappy surroundings, momentarily at least, if perchance he finds himself engaged in an occupation the apex of whose success is, let us say, power over the force of nature.

In both pure science and industrial research the men who succeed will be, for the most part, those men in whom the element of curiosity about nature and her ways is a controlling urge. With similar desires and similar training the forces which tend to place the individual in the pure-science field or that of applied science will be those secondary influences concerned with the allurements of the academic surroundings, the desire to have one's work concretely useful, or some of the thousand and one minor factors of propinquity, heritage, environment, or chance.

Except in a minor way, there is no large available reservoir in which we can fish for men of proved competency in industrial research. Here and there we may, if we are so minded, pick out a man who has won his spurs in the field of pure science and transplant him in our industrial-research orchard, or we may on occasion avail ourselves of an opportunity to transfer a man of maturity from one part of the industrial research world to another. Neither of these processes is, however, of any considerable value in strengthening industrial research. The first is a questionable procedure, particularly if indulged in freely, since the price paid for a temporary advantage is the almost certain degradation of the ultimate supply of trained men and new fundamental knowledge. The second is a mere shuffling of the cards in the deck, and in some cases is ethically objectionable.

Problem of Organization That of Finding and Training Competent Young Men

To those of us who are concerned with the building up and perpetuation of industrial-research groups to function effectively year in and year out, the problem of finding competent men boils down in the last analysis to our ability to find competent *young* men and, having found them, to bring them into the organization, provide them with the facilities and encouragements for growth, and ultimately to make leaders of them. For the most part our search leads always in the same direction, namely, to the institutions of learning and to the parts of those institutions where men are given advanced training in science. Out of the youthful timber which we find here we must make our selection. Occasionally the choice is easy—more often hard. To know and appraise a man well one must live and work with him for a long period. For the most part we who are in search of men do not have this opportunity. We must rely on such casual tests as our experience leads us to think worth applying. We should in the main be able to eliminate those who have inadvertently chosen an uncongenial occupation and who even though temporarily inducted into the industrial-research field will not continue there for long. We should likewise be able in many cases to eliminate those who while properly cast in the field of scientific research would nevertheless find the environment of the industrial-research laboratory distasteful as compared with the atmosphere of the college or university. Occasionally but not always we may be able to eliminate the precocious but superficially brilliant youth. It is from the remainder, after these eliminations, that we must make our choice. That choice should be entrusted to men of experience and understanding.

In my twenty-five years of association with industrial research I have had occasion personally to select a great many men. In the main I think I have had somewhat more than average success in the selections. Some, however, have proved quite wrong. Looking back over this experience of successes and failures, it seems to me that in the majority of the successes final judgment

was based about one-third on my personal appraisement and about two-thirds on the considered judgment of a baker's dozen or so of men in the academic world who had had a relatively long and intimate opportunity to observe the subject of choice. Per contra, in the majority of cases which were not successes I am inclined to think that too little attention was paid to the experienced judgment of those in the best position to know, or too much dependence was placed on the expressed opinion of those whose judgment I should have distrusted for any one of a number of reasons.

Advice of College Faculty Members of Great Assistance

Summed up, therefore, I should say that in attempting to select young men who in later life will be successful in industrial research, a primary requisite is to come to know the wise men in our college, university, and technical-school faculties whose judgment applied to the young men they have instructed makes them a more efficient sieve than any casual outsider can hope to be. True, they may not be able to tell you that "X" or "Y" is suitable for your particular situation—that is a matter which you alone are in the best position to judge. They should, however, be able to give you substantial advice, not only as to character but as to the reasonable chance that the youthful evidences of ability are the early fruits of a substantial continuing harvest and not merely the exotic flowering of a hot-air plant or the reflections of a casual environment.

In the matter of encouragement there is, I think, but little to be said. In a general way we of industry can give encouragement which induces young men to choose aright in the selection of their college and university training. More specifically, when competent men come to us we can see to it that their surroundings, the conditions of their association with their fellows, and the tools with which they work are congenial and adequate. Above all, we must see to it that a just recognition of their achievements is accorded them. While adequate monetary reward in the form of salary or otherwise is a necessary and very important part of the problem of encouragement, it is in many cases, beyond a certain point, less important to peace of mind and continued productivity than are the conditions of environment and of a sympathetic human understanding of things accomplished, of obstacles overcome, or of problems to be struggled with.

Neither with respect to the matter of choice nor the problem of encouragement are there in the field of industrial research, more than elsewhere, any hard-and-fast rules which can be applied with machine-like precision. We are human beings dealing with other, and, to a large extent, younger human beings. The constants and variables of our particular equations may differ, but they are still the same equations with which other groups in other fields are struggling to solve like problems. Our success or failure in the selection and encouragement of men in the industrial-research field is to a large extent a test of our individual sapiency. If proof be needed that the problem is susceptible of solution in many ways, we have only to look about us to see how widely dissimilar in point of view, experience, and method are the men who have unquestionably succeeded in building up effective industrial-research organizations in many fields of applied science.

The Invention of the Steam Hammer

By H. W. Dickinson,[1] London, England

From time to time the question is raised as to who should be credited with the invention of the steam hammer, and the facile reply that it was James Nasmyth satisfies all but a few, among whom are some who think that others ought to have the credit of the invention to his exclusion. There is thus an excuse for now setting down the facts as far as they are available.

It would be an obvious suggestion any time after the invention of the steam engine in the beginning of the 18th century that it would be a good idea to apply it to a hammer, but it is safe to say that no such application was made, firstly, because the engine although reciprocating was only single-acting and did not lend itself to the duty, and secondly, because the water wheel supplied all the power that was required for the processes then in use, which produced raw materials in small and manageable masses; e.g., if a large object such as an anchor was required, it was built up by successive small agglutinations of weld-iron.

When James Watt brought out his improved engine he was at once asked by John Wilkinson to apply it to actuate a hammer, and in 1777 did bring out a steam stamp[2]—"the Battering Ram or devil incarnate" is what Watt termed it—but we hear no more of it; probably it stamped itself to pieces. He had more success in 1782 in applying the rotative engine to take the place of the water wheel in tripping the tilt hammer, than the accepted type of power hammer.[3] This subsequently became established practice.

The first proposal for a vertical direct-acting steam hammer, is that of William Deverell, patented in 1806. He attached a hammer head to the piston rod, raised the piston by steam to its full stroke, exhausted the steam, and the hammer was assisted on the downstroke by the air compressed above it.[4] There is no evidence that such a hammer was ever constructed.

In France the ingenious M. F. Cavé, having occasion in his manufactory in 1835 to execute some repetition work, quite independently conceived the idea of a direct-acting steam punching and shearing machine with a hand-worked valve; this he constructed and for it he obtained a *brevet d'invention* in 1836; in the specification he expressly claims the application to a hammer.

Broadly speaking, therefore, the idea of a steam hammer, whether of the drop, tilt, or direct-acting type, was common knowledge both in England and in France at this date.

How James Nasmyth came to apply his mind to the steam hammer is well known. In 1839 the celebrated vessel the *Great Britain* was under construction by I. K. Brunel, and the forging of the paddle shaft presented difficulty. Mr. Francis Humphries, engineer of the Great Western Company's works, communicated his difficulty to Nasmyth in a letter dated November 24, 1839, and it was this problem that Nasmyth solved on paper in the wonderfully short space of a few hours.[5] Brunel discarded the idea of paddles in favor of a screw, and a propeller shaft of boiler plate instead of a forged one was decided upon; hence the hammer was not proceeded with and the sketch lay dormant in

[1] Honorary Secretary, The Newcomen Society. M.I.M.E.

[2] Dickinson and Jenkins, "James Watt and the Steam Engine," p. 111.

[3] Loc. cit., pp. 161 and 247.

[4] Cf. "Repertory of Arts," vol. IX, 2nd Ser., p. 387.

[5] Sketch Reproduced in "James Nasmyth, Engineer, An Autobiography," 1883, p. 241.

Nasmyth's "Scheme Book." The account which Nasmyth himself gives[6] of what followed is circumstantial, and is that M. Eugène Schneider, of Creusot, who was one of the firm's customers, and his engineer, M. Francois Bourdon, visited the Bridgewater Foundry at Patricroft. The precise date of the visit is not stated, but it was sometime in 1840. Nasmyth happened to be from home at the time, but the visitors were shown among much else the "Sketch Book" mentioned above. Now there cannot be any doubt that there was a call at Creusot for such a tool as the steam hammer, and it is quite likely that Bourdon was scheming something at the time. Indeed there is a working model of a steam hammer preserved at Creusot which is said to date from 1838, but no documentary matter in support of this date has so far been brought forward. However that may be, on October 20, 1841, MM. Schneider Frères & Cie applied for a *brevet d'invention*,[7] and on the 19th of April following this

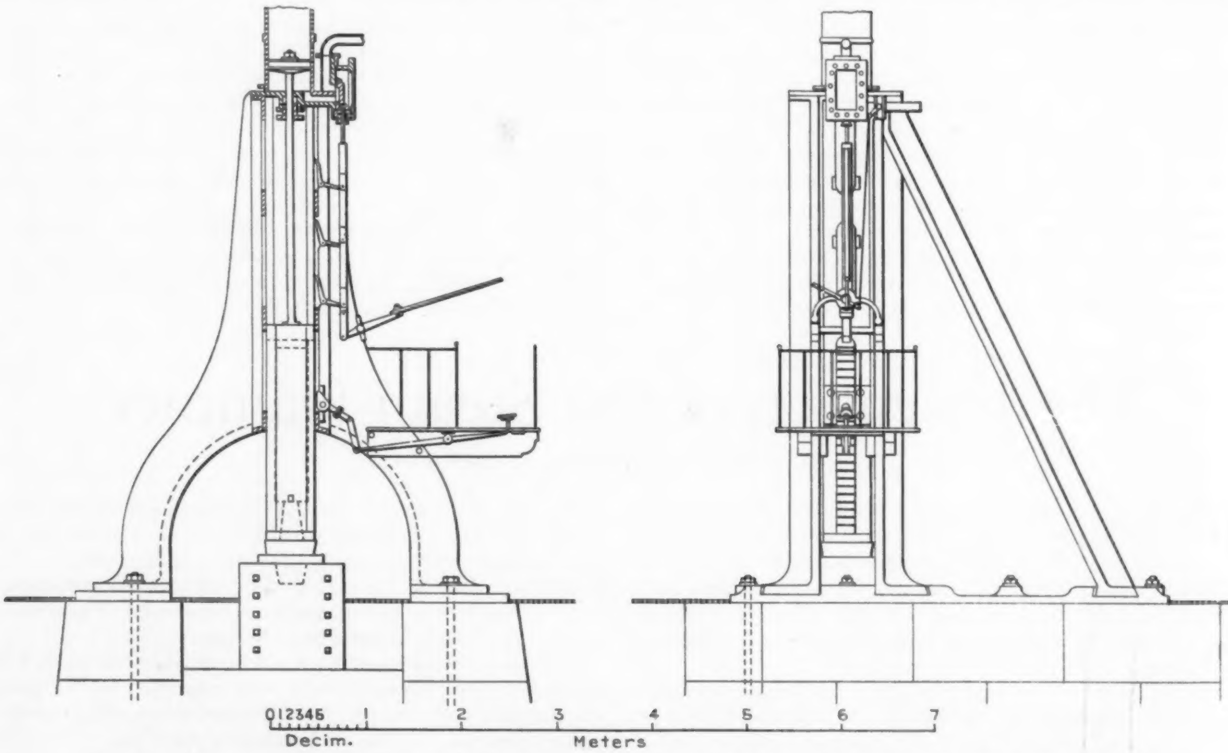


FIG. 1 VIEWS OF STEAM HAMMER IN APPLICATION OF SCHNEIDER FRÈRES & CIE FOR A FRENCH PATENT IN 1841

was granted. The specification is brief, being merely an enumeration of the principal parts, and the accompanying drawing, Fig. 1, which represents two views of the apparatus, shows the hammer head made of a prism of cast iron attached directly to the piston working within a single-acting cylinder. The prism serves as a rack with which to engage detents to be worked by the hand or the foot to stop the prism at the height judged necessary.[8] In other words, the specification discloses nothing novel, and therefore, strictly speaking, nothing patentable. Or if the rock can be called novel, then it may be said that what is novel is not useful, and what is useful is not novel.

[6] Loc. cit., p. 245.

[7] "Description des Machines. . .dans les Brevets d'Invention," vol. LXIV, p. 393.

[8] Armengand, Ainé, "Machines, outils et appareils," 1845, vol. IV, p. 362. This author considers that the arrangements shown in the patent were no advance on those of Cavé, and, while sufficient for a punching machine, were not suitable for a steam hammer that has to work continuously.

It was not long, however, before M. Bourdon produced a working steam hammer, because in a description of the Schneider Works[9] in 1842 in a report by M. Calla on establishments making stationary engines and locomotives, there is this mention: "*Nous devons faire ici une mention particulière du marteau à vapeur recemment établi par MM. Schneider pour l'exécution de les plus grosses pièces de forge.*" Then follows a short description and the promise of a complete drawing later; this promise, however, was not redeemed. Besides this Nasmyth himself saw it at work in April of the same year. Curiously enough, neither M. Schneider nor M. Bourdon took out any patent for the modifications and working details that rendered their hammer a success. Why they should not have done so if they had made such improvements, has not been explained.

On the other hand, Nasmyth, realizing the fact that his invention was now of commercial value, lost no time on reaching home in taking out a patent in England. This was in June, 1842. The specification is a model of clarity, beginning with an enunciation of the principles involved, which is followed by a description of the tilt hammer, pointing out its limitations and leading up to the novel features of his invention. The drawings are remarkably clear,[10] showing the general arrangement, the tappet gear, and the means for regulating the stroke at will, arrangements which rendered it a manufacturing tool capable of all demands upon it in the forge or the workshop. Nasmyth took out a similar patent in France in the same year. He subsequently took out a patent in U. S. A. also. He took out a patent for the self-acting gear in 1843; this has been claimed with great probability for Robert Wilson,[11] the manager and later a partner at Bridgewater Foundry, who introduced other valuable improvements in the hammer.

[9] *Bull. de la Soc. d'Encouragement*, Dec., 1842, p. 475.

[10] Cf. *The Engineer*, Nov., 1890, p. 406, *passim*.

[11] Rowlandson, "History of the Steam Hammer," 1864, p. 6.

The credit given to Nasmyth for the invention of the practical steam hammer does not seem to have been disputed seriously till 1871, when M. Eugène Schneider, in the course of evidence before a Select Committee of the House of Commons on the patent laws, stated (1893):

> In 1840, M. Thiers, then Minister, addressed himself to me to inquire whether I could manufacture for the French Government marine steam engines of 400 horsepower. I replied to M. Thiers: "I can manufacture all the mechanical parts, I can execute all the cast-iron pieces, but I have not the mechanical means which can forge pieces of wrought iron as large as those which are necessary." I further said: "I am going to England to see if there are any mechanical means which will enable such large pieces to be manufactured." Before starting for England, my chief engineer proposed to me a design for a hammer. I examined it, and found it good, but as it was new, I made the journey to England, and saw all the large works in England where large pieces were forged. I found nothing good there. I went to see Mr. Nasmyth, who is a man of great talent, a true inventor, in my opinion a great engineer. I talked over this problem with Mr. Nasmyth, and he brought out of his portfolio a design for a steam hammer. I discussed the design with Mr. Nasmyth and pointed out to him that his design was not practically good; he left his design in his portfolio and did not carry it out; I told Mr. Nasmyth, after saying that his design was not practically good, what it was that we intended to do, and I penciled it out for him to see. He made objections to our project; I returned home, having found nothing better than what my engineer had proposed to me, and I therefore had that design carried out. After our hammer had been at work for six months, Mr. Nasmyth came over and found it working very well; he penciled out in his sketch-book a hammer such as was performing its work at our place, and from this drawing he at once took out a patent in England, in Germany, and in Russia.
>
> (1684) In his own name? In his own name; he subsequently disputed the Creusot invention, and declared that he was the inventor of the steam hammer; I declare that Mr. Nasmyth was not the inventor of the steam hammer, but I declare also that I am not the inventor of the steam hammer.

M. Schneider impressed upon the Committee that quite a number of persons were then in search of some new means of raising a heavy weight in order to let it fall on the piece to be forged, which was quite true, and stated that: "When a problem like that is proposed there is always some one who solves it; I believe that we were the first to solve this problem practically." Asked whether this was a case in which he did not consider that it was proper to grant a patent, he replied (1685): "I did not believe that it was a proper subject for a patent. I did not ask for a patent. I will never ask for a patent for an arrangement of mechanical means tending to a very simple end, to produce an object of ordinary and common fabrication." This is in flat contradiction to the facts as cited above.

Nasmyth asked leave to appear before the Committee to "rebut a very improper personal allegation made by a previous witness," and when he did so, gave substantially the story as he relates it later in his "Autobiography." He was most emphatic, for example, asked (2257) "At the time of taking out the patent (i.e., 1842) had you modified your invention in any way, in consequence to anything you saw at Creusot?" he replied, "No, the invention as it exists in full practice to this day has all the features of my original sketch intact; they have never been altered, and the most important details are there." He did not, however, comment on Schneider's denial that he had taken out a French patent.

According to another story, Bourdon himself is credited with having taken out a patent in September, 1841.[12] The French official records do not bear out this statement.

Quite recently the statement[13] has been made that Mr. James S. Cox, who was employed at Creusot in April, 1842, i.e., at the very time of Nasmyth's visit, found a steam hammer at work there but kept secret. M. Bourdon, however, allowed him to make a drawing of it. This, as might be expected, closely resembles that in the patent specification as well as the model.

The title of the drawing: "Machine for forging large pieces invented at Creusot in 1841," is obviously not that of the original drawing.

Accepting the statements of both sides as correct, we then have this state of affairs:

Nasmyth's attention is drawn to the problem of forgings for marine engines in November, 1839, and he schemes a complete hammer. Schneider's attention is drawn to the same problem in 1840, and M. Bourdon proposes a design. Schneider comes to England, sees Nasmyth's design but does not think it is of practical value, and sketches for him Bourdon's proposal. Schneider on his return had this carried out between 1840 and November, 1841. The latter date is on the assumption that Nasmyth and Cox are right as to the date of the former's visit.

This date, too, is a month after Schneider had applied for a patent. The accompanying drawing, Fig. 1, shows nothing novel, but it is possible this was intentional—patents are taken out for many reasons. The model, the patent-specification drawing, and the actual drawing as copied by Mr. Cox show substantially the same design but one having a strong family resemblance to that of Nasmyth's, in fact, such as a capable engineer like Bourdon could have produced after he had seen for a limited time a novel design. Nasmyth's patent drawing of 1842 is close to his sketch of 1839 and does not suggest any new influence in the interval. Hammers made thereafter according to the drawings functioned successfully. Bourdon's hammer was in experimental stage for at least 12 months. Nasmyth's was successful from the start.

Much turns on the question whether the date of the model can be established. Failing that, on the evidence of Mr. Schneider we must reject the date 1838 and conclude that although Bourdon, after probing in the dark for a year at least, with the knowledge of Nasmyth's sketch in his mind, did succeed in bringing the first successful steam hammer into being, yet it was Nasmyth's genius that supplied the details that made the steam hammer the astonishingly useful tool that it has since proved to be.

[12] C. Chomienne, *Railroad and Engineering Journal*, June, 1888, p. 254.

[13] MECHANICAL ENGINEERING, vol. 50, p. 869.

The Engineer

(Continued from page 438)

solution of the great problems which now confront the nation.

The World Engineering Congress to be held in Tokio is one of transcendent importance, not only in its economic aspect but in presaging as it does the spirit of cooperation among the great scientists of the world to carry on research and to interchange information of inestimable value to industry and to the progress of civilization.

"By mutual confidence and mutual aid great deeds are done and great discoveries made." Science recognizes no political boundaries. No tariff walls or embargo can prevent the interchange of results of scientific investigations which promote the higher standards of living and well-being of people of all nations.

It is with deep regret that I shall not be able—if you will excuse the personal note—to attend the Tokio Congress.

My intercourse with the engineers of Japan several years ago when I visited that country afforded me not only great pleasure socially but an inspiration for my professional work. I need not assure you of the delightful hospitality you will receive in that country, famous for its hospitality, nor of the admiration with which you will regard the achievement of our Japanese confrères, and that you will return to this country with a genuine affection for the people of Nippon, the Land of the Rising Sun.

The Navy and the Engineer

Problems of Weight Economy in Cruiser Construction—The Merchant Marine and the Navy, and Their Value in Promoting Good-Will Abroad—Increase in Foreign Trade When American Vessels Are Available—The Matter of Preparedness

By Capt. C. S. McDowell, U. S. Navy

THE naval officer of today is primarily an engineer. Practically every one of the special duties to which an officer may be assigned on board ship is an engineering job, requiring engineering training and an engineering mode of thinking. It used to be said of some of our captains twenty-five years ago that they didn't know what they had down below that made the propellers go round; they regretted the passing of the sailing ship, and found fault with the chief engineer for fouling the deck with coal and cinders. Today our admirals and captains have had engineering training and experience, and the commanders of our fleets have learned to think as engineers and to handle their problems as engineering problems.

The Problems of Weight Economy

The Limitation of Armament Conference set certain maximum total tonnages in the different classes of craft and also placed an upper limit on individual vessels. We have the limit allowed for battleships, so these are not now being built, but we can still build airplane carriers, light cruisers, destroyers, submarines, and auxiliary craft. If we examine the case of the light cruiser we find that vessels are limited to 10,000 tons and that the size of gun must not exceed 8 in. The problem is to build the best possible ship on that 10,000 tons. Every ton saved by reducing weight where it does not affect the military characteristics of the vessel means a ton that can be put into more power, or more guns, or more armor, or ammunition, or fuel. Every increase in overall power-plant efficiency, from the burner tip to the propeller, means either increase in radius of action or elimination of weight required for fuel oil that can be applied to other characteristics. The final design of such a cruiser must of necessity be a compromise, weighing the various essential characteristics and endeavoring to get the best all-round ship possible for the average conditions to be met.

All engineers can be of assistance to the Navy by endeavoring to devise means for producing either material or equipment which the Navy has contracted for, of as light a weight as possible, without sacrificing required strength, durability, or efficiency.

The Navy was the father of the steel industry in this country, for when the question of steel and armor plate for our vessels arose in the eighties, there was not available in this country any plant to produce the material required. At that time the Navy sent abroad commissions to make a study of the foreign practices and to develop specifications for structural steel and armor plate. By placing orders with companies and by detailing officers, who gained this experience abroad, for following the production of steel, the industry was nursed along until it became self-supporting.

The development of the automobile industry has brought out many new alloys, some of which have been taken advantage of by the Navy, but possibly many others could be used to advantage. At any rate, constructive criticism of existing Navy specifications would certainly be welcomed.

Presented at a meeting of the San Francisco Section of The American Society of Mechanical Engineers, San Francisco, Calif., October 25, 1928.

In our cruiser program the use of aluminum alloys must be taken advantage of if we are to produce a vessel containing the greatest possible value on the 10,000-ton limit. We are faced here with a somewhat difficult problem in that the commercial aluminum products are very corrosive when exposed to salt and moisture. This problem of corrosion applies of course to all the materials which the Navy uses on its ships. The material that is utilized may be non-corrosive, or we may use protective coatings, but protective coatings in themselves add weight. The paint alone used on the interior of a vessel means many tons of weight, so that if we use lighter-weight protective coatings, such as aluminum paints, we are making a saving in weight which may be utilized for other purposes.

Another saving in structural weight may be obtained by the development of new shapes so as to give the required strength of steel or alloys with a minimum weight, and by taking advantage of welding in place of riveting wherever possible. We may find, in endeavoring to save weight by welding, that we throw out the use of heat-treated steels, which we would want, so that we must again compromise and utilize alloy or heat-treated steels in certain places and ordinary steels in others. We may find that we could build the structure of a vessel that would be long lived so far as corrosion is concerned, but that its weight would be excessive and that a shorter-lived structure, with the knowledge that we would have to replace elements within a few years, would be more desirable in view of other characteristics gained.

To briefly summarize, we require the hull to be satisfactory in so far as strength requirements are concerned and of as light weight as possible, and protected against corrosion as much as possible without too great an addition of weight. Cost under such conditions is not a major consideration.

In the power plant, both main propulsion and auxiliary, of a cruiser we are given a certain maximum speed which it is desired to attain and a certain radius of action, and then are required to accomplish this with a minimum of weight. As is well known, the Navy has adopted electrical propulsion for major vessels, but it has been found that this cannot be utilized on cruisers because of weight and space requirements, and in the present development the only means of satisfactorily meeting the demands is a turbine reduction drive. It may be that the Navy is at present rather conservative in the use of high-pressure steam and superheat, and the possibility of using higher pressures or higher temperatures offers material advantages by giving higher efficiencies and therefore a saving in the weight of fuel that must be carried. There is also a possibility of saving in weight on main propulsive units by using lighter materials for casings, foundations, etc. The development of steel for shafting with a higher fatigue limit per unit of weight without a decrease in tensile strength, also offers opportunity for weight saving. The saving in weight by careful design of the propulsive units, with attendant shafting, may all be wasted if the same principle is not applied to all of the auxiliaries. The Navy has been fairly progressive in the development of the electrically driven auxiliary for practically every purpose, such as steering, anchor engine, deck winches, turret machinery, pumps, etc., and the develop-

ment caused by the Navy and the experience gained by it can be profitably utilized by the merchant marine.

In lightening up on our cruisers certain data may be of interest: Turbo-generators have been reduced from 78 lb. per kw. to 48 lb. per kw.; forced-draft blowers have been reduced from 163 lb. to 53 lb. per 1000 cu. ft. of air per minute; light-weight searchlights have been developed which save 10 tons on each vessel. New telephone systems have been developed, and this rather inconspicuous item has saved 11 tons per vessel, mostly in wiring.

The cardinal features of cruiser construction, namely, light weight and high efficiency without sacrifice of strength or durability, and non-corrodability, apply in practically the same degree to submarine construction; however, in submarines the space feature may take precedence over weight.

THE MERCHANT MARINE

The merchant marine is very definitely tied up with the Navy in wartime, and it cannot be expanded on the spur of the moment. On the other hand, the Navy in peace time can and should develop engineering practices equipment, and material which may be applied toward making possible an American merchant marine that may compete with foreign shipping. The Jones-White bill, it is hoped, will encourage construction of American bottoms of a modern type which will expand our merchant fleet.

It is realized, of course, that the labor in our shipyards is higher paid than abroad and that the crews of our merchant ships are higher paid than foreign crews. The American manufacturer, or producer of food materials, is concerned with the cost of transporting his goods from the place of production to the place of utilization. In foreign trade his production cost, in reality, includes transportation to the ultimate consumer. It is my belief that the engineer of today has a real mission in lowering these transportation costs from the factory or central food warehouse to the ultimate destination. There are many features involved in this cost, and it includes the first cost of a vessel, the operating cost of the vessel, the cost of handling from the factory to the original conveyor, rehandling at terminals, both in this country and abroad, and the time involved between originally starting on its journey from the factory to its final destination. We may possibly afford a higher original cost for vessels and a higher wage bill on board the vessels if we can reduce terminal charges and the turn-around time of vessels. I believe that if some of the same intensive engineering talent is applied to the handling of goods that has been used in the development, for instance, of the automobile, we shall find that high wages are not a hindrance to the transporting of goods in American ships.

I believe that every manufacturer and every engineer is directly concerned in the development of a satisfactory American merchant marine. There is involved in this problem not only the question of transporting goods cheaply, but also that of opening up new markets. I am certain that American shipping means greater markets for American goods throughout the world, for it establishes contacts and a knowledge of American products which the foreign flag cannot do; therefore, if this country is to depend more and more upon foreign markets for our continued prosperity, the development of our merchant marine to the point where we shall carry at least fifty per cent of our foreign trade is necessary.

We more or less assume that shipping cannot be built in American yards as cheaply as abroad because of our higher wages. I believe that there is some question about this. We have proved in other industries that we can pay high wages and still produce cheaply, and the same general principles apply.

About a year and a half ago the Navy Department opened bids for eight light cruisers. At that time I was the engineer officer at the Mare Island Yard, and it was decided that we, at that yard, would submit a bid in competition with private shipyards and other Government navy yards. After careful, detailed estimates we submitted a bid which was three million dollars less than the lowest bid from any private shipyard, and one million dollars less than the lowest bid from any other navy yard. As a result of its bid, Mare Island was awarded the contract to build one of these cruisers, although I imagine that the people in the Navy Department, as well as the private shipyards, felt that we could not build as cheaply as we had stated we could. The keel of this vessel has only been laid some few weeks and the actual cost of the completed vessel cannot now be stated, but I feel confident that the actual cost will be very close to our estimates, and that a vessel can be built even cheaper than we estimated, without in any way sacrificing workmanship or material.

There is no question but what there is a difference of opinion over the desirability of building Government ships in Government navy yards. The private shipyard is a distinct national asset and must be encouraged and assisted, if necessary, by the Government in order to keep going, but it is my opinion that the competition furnished by the Government yard is a distinct advantage in forcing improvement of practices and equipment at the private yard, in order to bring down private-yard costs, and if the Mare Island Navy Yard shows in the construction of the light cruiser *Chicago* that they can build such a vessel at a much lower cost than private yards are now building such vessels, it should be of a distinct advantage to the private yard and to the ship-owning companies.

It is also generally believed that the operating costs of our merchant vessels must be higher than those of foreign vessels, due to the higher wages of the crew. Into the operating cost enter such items as fuel, lubricating oil, maintenance and repair material, and charges that keep piling up while a vessel is in port discharging or loading or awaiting cargo. The fuel bill can be materially reduced if improved and more efficient types of main propulsion are used; this may be Diesel drive, or Diesel-electric drive, or high-temperature steam, or a combination. The question of efficient auxiliaries is nearly as important as that of efficient main propelling units. In many cases fifty per cent of the power generated, taken throughout the year, is utilized in auxiliaries. If attention is paid only to efficiency in main units and the auxiliaries are not also developed to give the greatest efficiency, all gains in fuel obtained from main units may readily be lost in wastage in the auxiliaries. More efficient auxiliary power causes a direct reduction in operating expenses. It may be noted that many auxiliaries are running continuously and that they are piling up charges during the time a vessel is in port.

Repair and maintenance charges can be reduced by attention to durability in apparatus and by careful training of personnel in using apparatus.

VALUE OF NAVY AND MERCHANT MARINE IN PROMOTING GOOD-WILL ABROAD

I should like to stress somewhat the value to the manufacturer and producer of the Navy and the merchant marine during peace time in producing good-will for this country throughout the world. We all realize how intangible good-will is, and also how essential. We know that in dealings between companies, more satisfactory results are obtained if there is a feeling of personal contact with representatives of the various companies. The same principle, I am sure, holds true in foreign business. In many parts of the world the principal contact that the people of a particular country have with the United States is through the Navy and the merchant marine. Our officers and men represent a cross-section of the people of this country, and in their personal dealings when ashore in foreign countries with the peoples of those countries they give some feeling of acquaintanceship with

the whole United States. When merchants in other countries, who have had personal contact with American officers and men, write back to this country for information or for products, they have some feeling that they are dealing with friends.

Twenty years ago President Roosevelt sent our fleet on a cruise around the world. This fleet was gone some fourteen months and visited many of the principal ports on all continents. President Roosevelt, after his retirement, stated that he believed history would record that one of the greatest acts of his career was this world cruise, which, in his opinion, had done as much to promote world peace and understanding as any other act during his time. I believe that in reality, in addition to promoting friendship and understanding, this cruise served to show the people of the many countries what America could produce in the way of materials, as represented by these vessels and their equipment. It was my personal experience at that time to have received comments from various citizens of different countries, giving their favorable impressions of motors, generators, pumps, etc., which they had seen on board ship, and I have no doubt that this cruise created considerable increased trade for our manufacturers.

Increase in Foreign Trade When American Vessels Are Available

That our foreign trade has increased when American lines have been provided can be shown by a few examples: In 1914 only five U. S.-flag vessels operated to South American ports. The total value of our trade with South America during that year was $347,217,000. On June 30, 1928, there were eighty-nine American vessels in the South American trade. The value of our South American trade for 1927 was $1,000,000,000 and consisted of about 13,000,000 cargo tons, and was 13 per cent of our water-borne foreign commerce for 1927.

Prior to the Great War there was only one American-flag line operating to the Orient. The average annual value of our foreign commerce for the five-year period of 1910 to 1914 was less than $380,000,000. The volume of trade with Asia in 1927 was $1,800,000,000, and on July 1, 1928, one hundred and forty American-flag vessels were employed in the Oriental trade.

Similar increases are noted in trade records with Africa. Prior to the war there was no service by American vessels to that continent, and the average annual trade from 1910 to 1914 was about $47,000,000 a year. There are now nineteen American-flag vessels employed in the African trade, and the value of our 1927 trade with Africa was over $200,500,000. These examples might be taken as a rather glowing picture of our merchant marine, if we didn't all realize that nearly all the vessels employed in our foreign trade were wartime products and that our new construction has practically stopped. Foreign countries are rapidly replacing their shipping with modern vessels faster than ours and more economical in operation. Unless we start rebuilding our merchant marine, we are going to find ourselves again, as in 1914, with practically no merchant marine, and such a condition will affect our foreign commerce.

At the present time American-flag vessels carry about one-third of our foreign water-borne commerce. We should be carrying at least fifty per cent of this commerce, and preferably sixty per cent. The annual sum paid for passenger and freight transportation in our commerce is about one billion dollars, and if we were to get sixty per cent of this, or $600,000,000, it would be an important factor in our balance of trade.

Preparedness

The Navy and the merchant marine are of necessity closely interlocked, and the engineer of today is required to develop them. Practically our entire merchant marine becomes part of the Navy in wartime, providing transports for troops, cargo ships for supplies of all kinds, hospital ships, repair ships, and all the other special services that must be supplied to a large force operating away from our immediate coasts.

A naval officer naturally desires war less than practically any other man in the country, but we must exert our every effort to be prepared in case a war should be decreed by the people of the country. The Navy, though, and an efficient merchant marine are our best means of preventing wars. In the first place, it is difficult to have a war between nations which understand each other's viewpoints, and our ships in foreign ports do promote understandings and friendships; and in the second place, if a foreign nation should be controlled by an aggressive, world-bullying group, they are not going to attack this country, no matter how rich we may be, if we are prepared to defend ourselves on the sea and are in a position to keep them from reaching our coasts.

A year ago there was held at Geneva a conference between Great Britain, Japan, and the United States to endeavor to set limits of total tonnage to be allowed the three countries in the light-cruiser, destroyer, and submarine classes. This conference was a failure because of the inability of Great Britain and our country to agree, and our lack of suitable merchant marine was, to a great extent, a cause of the disagreement. We had made a proposition that a total of 300,000 tons each in light cruisers be allowed to Great Britain and the United States, with the size of cruiser remaining at 10,000 tons and the caliber of guns at 8 in. Great Britain desired to limit the number of 10,000-ton cruisers to a very few, but to allow about 500,000 tons of cruisers of 6000 tons and mounting 6-in. guns. The smaller cruiser was not suited for us as its radius of action would be reduced, and we have not the large number of fueling bases that Great Britain possesses. Also, the limiting of the size of guns to 6 in. meant that all British fast merchant vessels could, on the outbreak of war, be quickly converted to effective cruisers by equipping them with 6-in. guns, which they can carry; they cannot be readily adapted to take 8-in. Therefore, as we lacked satisfactory merchant vessels, we would be immediately hopelessly outclassed in trying to protect our commerce, our convoys, etc.

I want to conclude by stating that it is of vital importance, for the security of our country and the maintenance of our prosperity, that we possess both a Navy and a merchant marine which are the equal to those of any other country. We want them to be the equal in numbers and a little better, ship for ship. To accomplish the desired results we shall require all possible engineering assistance. An efficient Navy and an efficient merchant marine are major engineering problems, and must be solved by the engineers of the country.

Too Swift for Prophets

SOME statistically minded American has computed that 30,000,000 people in this country now earn their living from five major industries which were non-existent, or nearly so, 25 years ago. Whether there are that many or half as many matters little. That some millions have occupations that were unknown a quarter of a century ago shows how rapidly the milestones are being passed. The industries involved are automotive, motion-picture, radio, chemical, and electric.

All five of these industries involve iron and steel and other metals in a large degree, automobile building having taken the lead in steel use.

The prophet of the steel industry about 1900 who could have foreseen the new fields of demand would have found little honor in his own industry. Yet the quarter-century was to see a new leader in consumption of steel arise from an infant industry. *Iron Trade Review*, April 11, 1929, p. 1004.

The Technical Institute—European Examples and Their Significance for American Education

By W. E. WICKENDEN,[1] NEW YORK, N. Y.

The American system of technical education has developed in a very one-sided manner. It is plain that technical education has never been conceived as a national problem and thought out as a whole. The term "technical institute" is the best common designation for schools of a non-university type which work on an age level above the secondary schools. There are admirable examples in the more carefully planned European systems for which we have few counterparts. Through great diversity of name, organization, and program runs a common warp of distinctive characteristics: they are not trade schools nor are they preparatory schools for higher studies; their courses are of a terminal character and are intended for young men already oriented to industry who wish intensive preparation for definite lines of advancement; most of their students are not book-minded; direct processes of teaching and learning are employed; and most of the student's work is done on the premises. The entire process is pointed to the higher practical pursuits of industry rather than to its highly intellectual functions. In addition to engineering courses of a fairly general, though practical, character, these schools provide nearly all the higher training in the technology of specific industries and training for particular technical functions.

Examples are cited from the higher schools of mechanic arts in France, which train definitely for the supervision of industrial production; from the local technical institutions of Great Britain, which form the apex of each local unit of the educational system and give the higher forms of continuative education for men employed in industry; and from the higher schools for machine construction, building construction, and specific industries in Germany, which accept students only after a considerable period of industrial experience.

In conclusion, the author favors the policy of recruiting a much larger proportion of our higher technical personnel from men who already have had normal industrial experience. For that purpose, there is need of a second and more flexible ladder parallel to the university system; we may look to this agency to train men for the supervision of industrial production, installation, and operation and to train in the operative technology of specific industries. The author recommends that these schools admit students primarily on evidence of their capacity and interest rather than formal scholastic credentials, that they should shape their programs on detailed analyses of actual vocational usages, and that the teaching processes should be based on direct instruction and experience, resembling in a more organized manner the learning processes in industry. He recommends incentives in the form of national certification. The potential field for full-time and part-time work in technical institutes appears to be at least double and probably treble that which properly belongs to technical schools of university type. Experience here and abroad indicates that separate schools are needed for these two functions. The major responsibility for filling the present gaps appears to rest upon the states and larger industrial cities, with the national organizations of the engineering profession exercising a role of guidance in the absence of any national ministry of education.

THIS study is an outgrowth of an extended investigation of engineering education. When we compared our practices with those abroad, we found our system of technical education to be the most one-sided of all; we were doing some things well, and others, equally important, we were scarcely doing at all. Certain historical influences had led us to concentrate much the greatest part of our effort in a single compartment of our educational structure—the college. We had multiplied courses of professional training in engineering beyond all parallel, but had largely neglected the training of the supervisors and technicians of industrial production, of contractors and builders, of operating and maintenance personnel for the technical services, and of skilled craftsmen of every sort. When we studied the distribution of engineering graduates relative to the needs of industry we found a like one-sided situation—the technical staff positions fairly well filled, the line officers of production and operation inadequately recruited. When we studied the personnel records of the colleges we found that on the average only 40 engineering students in 100 complete their courses and receive degrees. The obvious inference is that either the colleges are less selective than they should be or that the instruction they offer is poorly suited to large numbers of young men seeking a technical education. The engineering colleges may be likened to an overdeveloped right arm on a dwarfed and unsymmetrical body, unable to function at its best for lack of bodily coordination.

It is plain that technical education has never been conceived as a national problem in the United States and never thought out as a whole. With the exception of the Morrill Land-Grant Act of 1862 and the Smith-Hughes Act of 1917 in aid of vocational education, it has been left to local or private enterprise. A well-coordinated system will never develop in this way. It is important to get some concerted national thinking on the subject. In the absence of a national ministry or board of education much of the initiative must come from the major professional and industrial organizations. It is so even in bureaucratic Germany, where the central guiding and coordinating agency, the German Committee for Technical Education, was established and is largely sustained on the initiative of the Verein Deutscher Ingenieure.

The Technical Institutes. The term "technical institute" is the best common designation for technical schools of a non-university type which work largely on the post-secondary age level. There are admirable examples in Europe for which we have but few counterparts. These schools differ in name and organization from country to country; there is great diversity of detail in their programs, but there is a common warp of distinctive characteristics which runs through them all. The technical institutes stand quite clear of the conventional systems of secondary schools and universities which prepare for the highly intellectual professions, except a few in Great Britain which are combined with

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NOTE: Statements and opinions advanced in papers are to be understood as individual expressions of their authors, and not those of the Society.

university functions. They are not trade schools aiming at proficiency in crafts and processes as their primary end nor are they preparatory schools for higher studies. Their courses are of a terminal character and are intended for young men who have already become oriented to industry and wish specialized and intensive preparation for definite lines of progress. Their courses are shorter and more directly technical than those of the university professional schools. They include only a few indispensable complements of general education, and the mathematical and physical sciences are not taught as independent disciplines, but in intimate connection with their technical applications.

Most of the students in technical institutes are not bookminded; direct processes of teaching and learning are widely employed, with less emphasis on reading and independent study, and the greater part of the student's work is done on school premises under direct supervision. The entire educational process is pointed to the higher practical pursuits of industry rather

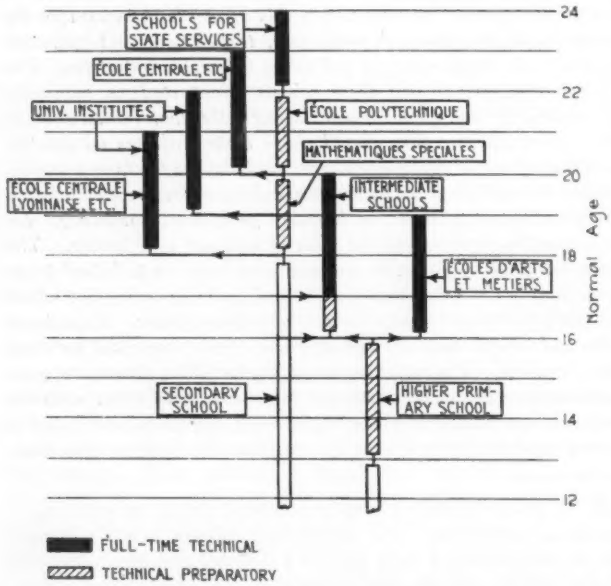


Fig. 1 French Technical Schools in the National Scheme of Education

than its specialized intellectual functions of research and analytical design. The courses of instruction fall into three distinctive types: (1) engineering courses, which parallel the university courses in more intensive and practical form and which prepare for a wide range of positions without specialization in any subdivision of industry, any specific function, or any branch of operative technology; (2) technological courses in specific branches of industry, such as textile manufacturing, printing, coal mining, building construction, foundry practice, and the like; and (3) functional courses, such as power-plant operation, quantity surveying, textile designing, and the like. The two latter types have little if any counterpart in the university system.

In the following sections a brief account is given of the place which schools of this character occupy in the educational systems of France, Great Britain, and Germany, typical programs of work are shown, and their methods are briefly described.

The French Higher Schools of Mechanic Arts

The National Educational System. The French have pushed their belief in separate forms of education for intellectual pursuits and for practical pursuits nearer to its logical limits than any other Western nation. France has two distinct systems of education, each complete in itself. One is intended to transmit a cultural heritage and to form an intellectual elite for the future leadership of the national. The other prepares for citizenship at large with a substantial base of general knowledge and a superstructure of vocational training. Each system has its own group of higher technical schools, the one preeminently professional in aim and intellectual in emphasis, the other preeminently industrial and practical. A small group of engineering schools occupy intermediate ground. (See Fig. 1.)

The primary schools of France serve nine-tenths of the population and provide a great reservoir of talent for higher technical training. The lower schools offer a uniform program to the age of 12, then ramify into industrial, agricultural, and commercial branches. There are numerous excellent trade schools (*écoles professionelles*) which may be entered at this stage. The higher primary schools in the larger centers have a three years' course beginning at the age of 13 which leads to much the same level of achievement as an American technical high school. The higher schools of mechanic arts (*Écoles d'Arts et Métiers*) constitute the apex of the primary system and are attended by its ablest graduates, chosen by a severe competitive examination. These schools train definitely for the supervision of production in mechanical industries, a realm in which they are unsurpassed in all Europe.

The Concours of Admission. The leading French technical schools all limit their admissions strictly through a severe competitive examination known as a *concours*. No one in France conceives it to be a public duty to provide higher technical education for all comers. The highly selective plan of admission insures homogeneous student bodies of marked ability and disposes in advance of practically the entire problem of elimination and of scholastic discipline. The *concours* for *Arts et Métiers* is commonly taken at the age of 16 or 17. There are two stages; the first is eliminatory and consists of written examinations in French, mathematics, physical sciences, and an optional foreign language, together with tests of lettering, sketching, and machine drawing. The final tests are oral, combined with a performance test in the manual arts. The entire series would be considered as severe by graduates of our best high schools. About one candidate in four or five wins the coveted prize of admission.

Organization and Regime. There are six national schools which are alike in all essential matters. Each serves a well-defined area, from which an annual promotion of exactly 100 students is admitted. The school at Paris, which serves only the metropolitan area, takes day students exclusively; the other five admit boarders at a very low charge for subsistence. No charge is made for tuition. Because of these advantages and the excellence of the training the competition for entrance is intense. The students are the pick of the entire primary system, a strikingly sturdy, intelligent, industrious, and wholesome type.

The three-year course of instruction is uniform for all, but some degree of specialization is allowed in shop practice. The program has been elaborated by a national commission, in which leading industrialists and engineers were represented, with minute care for the orientation of every item to the central purpose of the schools—the supervision of production—and is a striking example of French logic. The time is divided most systematically. Half of each morning is given to oral courses and conferences on scientific, technical, and economic subjects, and half to drafting and laboratory exercises and to specific instruction in mechanical technology. Five hours of the afternoon, excepting the half-day reserved for military training, are given over to systematic shop training on commercial production. Everything the student produces must pass the test of saleability, but the pace of the work is adapted to learners.

Curriculum. Because of its unique character, the program is outlined in detail as follows:

PROGRAM OF ÉCOLES D'ARTS ET MÉTIERS

Lectures and Conferences on General Subjects

First Year	Second Year	Third Year
French ... 32	Social and industrial legislation ... 16	Economic history ... 32
Industrial hygiene ... 16	Economic geography ... 32	Scientific management ... 16
Algebra and analytic geometry ... 32	Calculus ... 15	Applied mechanics ... 34
Trigonometry ... 14	Descriptive geometry ... 14	Hydraulics ... 21
Applied geometry ... 10	Kinematics ... 52	Heat power ... 43
Descriptive geometry ... 40	General mechanics ... 18	Industrial electricity ... 64
Physics (heat) ... 32	Physics (vibrations) ... 10	
Chemistry ... 32	Metallurgy ... 22	
	Accounting ... 16	

(Provision is made for seventeen selected laboratory manipulations in industrial physics, chemistry, and metallurgy during the first and second years, and for an unspecified number of measurements and tests in the laboratory of electrotechnics during the third year.)

Lectures and Conferences on Technical Construction

First Year	Second Year	Third Year
Masonry construction ... 2	Framed and concrete construction 10	Architecture of machines ... 5
Carpentry ... 5	Machine elements ... 22	Power machines ... 27
Machine elements ... 25		

Exercises in Drawing and Design

First Year	Second Year	Third Year
Conventions ... 1	Structural framing and assemblies ... 3	Boiler design ... 2
Helix, screws, bolts ... 1	Metal stairway ... 1	Design of part of a machine tool ... 1
Machine parts ... 7	Crank rods, eccentrics ... 1	Design of a sample structure ... 2
Wooden framing ... 1	Pistons and valves ... 2	Design of a crane or hoist ... 2
Conic sections ... 1	Machine-tool parts ... 2	Design of a steam condenser ... 1
Graphs of functions ... 1	Cams and gears ... 3	Design of a pump ... 1
Applications of descriptive geometry ... 3	Applications of descriptive geometry ... 3	Design of an electric or gas motor ... 1
Plan of a building ... 1		

Shop Practice and Conferences

	First Year		Second Year		Third Year	
	Conferences	Weeks of practice	Conferences	Weeks of practice	Conferences	Weeks of practice
Bench and machine work	12	17	10	35*		13
Pattern making	5	6	3	9 } *	1	5
Foundry	5	6	5	26 } *	4	5
Forging and heat treatment	6	6	5	35*	5	5
Electrical construction					4	4
Shop office						2
Laboratory testing						1

* Separate sections in the second year.

(The work in the shop office covers scheduling, time studies and records, and cost finding. The week of laboratory tests deals with combustion and vaporization, the efficiency of prime movers and mechanisms, and the properties of materials. Electrical construction includes windings, assemblies, and shop tests.)

The only element of specialization is in the shop practice of the second year, with the class sectioned in the following proportions: bench and machine work, 55 to 80 per cent; pattern and foundry work, 15 to 25 per cent; forging and heat treatment, 5 to 20 per cent. It will be noted that every item of the program has been directed to a single end—training for the direction of industrial production. The entire work in mathematics has a strong geometrical quality. Physics as such is limited to heat, changes of state, vibration, and radiant phenomena; the other aspects are taught as parts of the technical sciences. Chemistry deals first with thermochemistry and equilibrium then passes on to the various raw materials of industry. These three subjects are taught in a closely interconnected manner and with a direct view to their industrial utility, yet the treatment within its limits is rigorous and in a sound scientific spirit. The laboratory exercises in physics, chemistry, and metallurgy are arranged in a unified series dealing with such matters as high temperature measurements, calorific values, measurements of gas flow, properties of flue gases, qualities of lubricants, properties of fuels, dosage of metallurgical operations, welding, properties of alloys, and metallography. The emphasis given to social and industrial economy will be noted. The technical studies are developed strongly in the second and third years and are closely paralleled by the exercises in drawing and design.

Equipment. The war produced a great accumulation of surplus industrial equipment in France, and the period of liquidation which followed enabled the Ministry of Education to modernize and diversify the installations to exceptional advantage. Each plant provides simultaneous working space for the entire student body of 300, and the Paris school provides in addition for a special post-graduate year in foundry practice. The scale of installation may be judged from the fact that the shops and shop offices of the Paris school cover a floor space of more than 70,000 sq. ft.

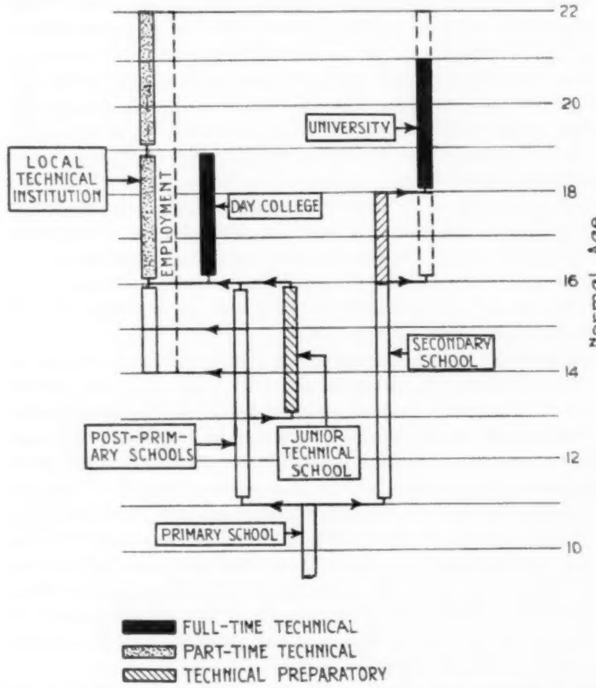


FIG. 2 TECHNICAL SCHOOLS IN THE ENGLISH EDUCATIONAL SYSTEMS

Importance of the Schools. These schools have been in high favor with the French industries for more than a century. Certain politicians sought to suppress the three then existing in the budgetary crisis of 1850, but industrial leaders rallied to their defense with such effect that their existence has never since been questioned. There is strong pressure from some provincial centers to have the number increased. At present the *Écoles d'Arts et Métiers* supply about 40 per cent of the higher technical personnel trained in France and fully two-thirds of the total in mechanical engineering. They are recognized by the state as part of the system of higher education, and their graduates receive the official title of *Ingenieur d'Arts et Métiers.*

THE LOCAL TECHNICAL INSTITUTIONS OF GREAT BRITAIN

Place of Technical Education in the English and Scottish Systems. Primary education ends at the age of 11 plus in England and at 12 in Scotland. Here the paths divide: one leads through the secondary school and the university to public life and the intellectual professions; the other passes through the post-primary schools to the end of full-time schooling at 14, 15, or 16 and on into the higher forms of continuative education. Taking 100 youth in English primary schools, 35 will continue their full-time schooling beyond the compulsory limit of 14, but only 12 of this number will enter the secondary school and only 1 the university; hence the great importance of higher continuative education running parallel with practical pursuits. This need is met in a most effective way by the local technical institution which stands at the apex of each geographical unit of the educational system. There are more than 200 such institutions in England alone. (See Fig. 2.)

Character of the Technical Institutions. The outstanding merit of these schools is their complete adaptation to local needs. In some small borough one may find a made-over building with the simplest of equipment, presided over by a full-time principal and a staff of part-time teachers from local crafts and industries, and a modest group of evening courses in drawing, elementary science, and trade subjects; while a large industrial center may boast a vast polytechnic institution with elaborate laboratories, shops and ateliers, a highly qualified professorial staff and many auxiliary trade teachers, a wide range of professional and vocational courses in both day and evening classes, and an enrolment running into the thousands. This admirable variety is the result of a happy combination of national aid and local direction. Half of the support comes from the national Board of Education, which exercises through its inspectors some degree of advisory control, but the real direction comes from the local education authorities. Full-time teachers have virtually the same status and salaries under a national award as secondary teachers, but individual treatment is accorded to principals, to heads of departments, and to men of professorial rank in day technical colleges affiliated with universities.

In England each local institution is self-contained, with some reciprocity between adjacent districts. The London County Council, however, is an autonomous unit, and its many schools make up an interconnected system. In Scotland there are regional groups of evening schools in small centers coordinated with central institutions giving more advanced work. Three of the central institutions have day colleges affiliated with neighboring universities. Exceptionally able students may obtain bursaries to assist them to transfer from evening to full-time classes. With wise economy of resources, Scotland has thus realized Huxley's ideal of technical education—"a ladder reaching from the gutter to the university, up which any youth may climb as far as his ability will take him."

The enrolments of men and boys for England and Wales in 1926–27 were about 390,000 in evening classes, 11,000 in part-time day classes, 11,000 in junior technical day schools (ages 13 to 16), and 4000 in post-secondary full-time classes, principally in engineering and chemistry.

Types of Instruction. The ideal of adaptability to individual and local needs has led to a considerable variety of types and levels of instruction, as follows:

Full-Time Instruction	Evening and Part-Time Instruction
Junior technical schools:	Preparatory courses
Pre-engineering courses	Junior courses
Craft courses	Minor courses in crafts
Day technical colleges:	Major courses:
Engineering courses	Engineering } { Senior
Science courses	Technological } { Advanced
Technological courses	

There are a few monotechnic schools in the London area, principally for the building and printing crafts, but all others are of the polytechnic type. The grouped course has become universal in England, but both grouped courses and single subjects are offered in Scotland. Referring to the foregoing tabulation, evening courses in elementary subjects are classed as preparatory; junior courses are of two years' duration and are suitable for those who left the day school at 14; senior courses are of two or three years' duration and are suited to those who have completed a junior course or those who have left the day schools at 15 or 16; advanced courses are suited to older students and reach, within the limits covered, the standards of university work. Major courses extend through both the senior and the advanced stages, while minor courses are confined to the senior stage only. A minor course usually prepares for some skilled craft within an industry, while a major course is related to an industry as a whole or to the higher posts in any part of it.

The wide range of instruction offered by the larger institutions may be illustrated by the Municipal Technical College of Huddersfield, an important textile and engineering center:

TECHNICAL COURSES GIVEN BY A LARGE LOCAL INSTITUTION

Major Part-Time and Evening Courses

(S denotes the senior and A the advanced grade.)

Course	Years and grade	Credentials	Course	Years and grade	Credentials
Woolen yarn	3S, 2A	Dip.	Dyeing	4S, 2A	Nat. Cer.
Worsted yarn	3S	C.&G. Cer.	Civil engineering	3S, 2A	
Weaving and designing	3S, 3A	Dip.	Mechanical engineering	3S, 2A	Nat. Cer.
Cloth finishing	4S, 1A	Cer.	Electrical engineering	3S, 2A	Nat. Cer.
Textile mfg.	3S, 3A	Dip.	Building	3S, 2A	Dip.
Loom tuning	4S	Cer.	Plumbing	3S, 2A	Cer.
Chemistry	4S, 3A	Dip.; Deg.	Coal mining	6S, 6A	Dip.
Gas engineering	3S, 2A	Nat. Cer.			
Minor Evening Courses					
Breadmaking	3	C.&G. Cer.	Ironfounding	3	Cer.
Confectionery	3	C.&G. Cer.	Woodworking	2	
Mechanical engineering	4	Cer.	Carpentry	3	Cer.
Pattern making	3	Cer.	Electrical workshop	3	Cer.
Motor engineering	4	Cer.	Telephony	4	C.&G. Cer.
Full-Time Day Courses					
Chemistry	3	Dip.; Deg.	Electrical engineering	3	Dip.; Deg.
Dyeing	3 or 4	Dip.	Science	3	Dip.; Deg.
Wool textiles	3	Dip.	Architecture	3	Cer.
Civil engineering	3	Dip.; Deg.	Architecture	2 Adv.	Dip.
Mechanical engineering	3	Dip.; Deg.	Commerce	3	Dip.

The institution gives no degrees in its own right, but prepares matriculated students in certain courses for the external degree of the University of London. In many cases where the diploma or certificate of the local institution is awarded, the student has the option of taking the examinations for the certificate in technology of the City and Guilds Institute, a national examining and certificating agency of wide repute. National certificates are awarded by the Board of Education in conjunction with a group of professional institutions.

Day Technical Colleges. The local institutions in the larger centers, including a group of London polytechnics, maintain day technical colleges of virtual university rank. At Bristol, Manchester, Aberdeen, Edinburgh, and Glasgow the local day colleges are affiliated with neighboring universities as faculties of technology, but their part-time and evening classes are not considered as university work. Other day colleges prepare students for the degrees of the University of London. All accept non-degree students, but insist on full preparation in mathematics and science. The students may be awarded the diploma of "associate" of the local college or may qualify for the national diploma of the Board of Education and a professional institution.

Characteristics and Limitations of Evening Courses. Great Britain is easily supreme in the extent and quality of her evening technical instruction. She has had long experience in this field, beginning with the Mechanics' Institutes of a century ago and continuing through the Science and Art Classes to the upbuilding of the numerous local institution in the last forty years. During the greater part of the last century the evening classes represented her major effort in technical education. This long experience has tended both to perfect the work and to reveal its inherent limitations. One result has been the nearly universal adoption of the grouped course. The classes meet three nights per week for a yearly session of from twenty-five to thirty weeks; the attendance averages six or seven hours per week and rarely reaches eight, and the individual average for a yearly session seldom exceeds 150 hours. Each evening is usually devoted to a single subject. Home work of three or four hours per week is expected, mostly in the form of practical problems and exercises. There is little book study, and the instruction is necessarily of a very direct character. Lecture methods prevail in the classrooms

but the groups are of moderate size and there is enough discussion to assure that the subject matter has been fully understood. Laboratory work is semi-individual.

The major courses are organized in two stages, seldom exceeding three years each and ending in a general examination for a certificate. An example of senior and advanced evening courses for the national certificates in mechanical engineering may be taken from the important institution at Halifax, as follows:

Senior Course in Mechanical Engineering

Subject	Hours per week — First year	Second year	Third year
Practical mathematics	$2^1/_4$	$2^1/_4$	$2^1/_4$
Engineering science	$2^1/_4$	$2^1/_4$	$2^1/_4$
Engineering drawing	$2^1/_4$	$2^1/_2$	$2^1/_2$

Advanced Course

	Fourth year	Fifth year	Sixth year
Practical mathematics	$2^1/_4$		
Mechanics and hydraulics	$2^1/_2$		$2^1/_2$
Heat engines	$2^1/_2$	$2^1/_2$	
Machine design		$2^1/_2$	
Materials and structures		$2^1/_2$	
Economics of engineering			$2^1/_4$
English and French			$2^1/_4$

The examination for the higher national certificate is taken at the end of the fifth year, but an additional endorsement may be gained by the work of the sixth year, which also completes the preparation for the Associate's examination of the Institution of Mechanical Engineers. The mathematics of the senior course covers selected aspects of algebra, geometry, trigonometry, graphic representation, and simple calculus. The advanced course adds certain complements of algebra and trigonometry, but consists mainly of calculus and its engineering applications. Engineering science is a composite course based principally on mechanics and heat, with applications and laboratory exercises on mechanical systems, materials, and simple engines. The technical courses of the advanced period each include their complement of laboratory work or drawing.

The value of this type of evening instruction, given on a nationwide basis, is extremely great, but its limitations have led to a widespread effort, backed by the Board of Education, to introduce part-time day classes with attendance made compulsory by employers. Evening class work is essentially voluntary. It must be made popular to draw and hold attendance; it reaches the ambitious rather than the rank and file, and the employer has only a minor part in its direction. It is uneconomical to provide expensive laboratory facilities for evening use alone and difficult to maintain an efficient teaching staff solely for this service. Students come after a full day's work and cannot be at their best. The limited yearly total hours of attendance keeps the pace of advance slow and confines the course to narrow boundaries. With one full day of attendance per week and one evening in addition, a gain of 50 per cent in time is realized, making it possible to broaden the courses considerably and to work under far more favorable conditions.

Example of a Part-Time Day Course. The course given at the Woolwich Polytechnic for the apprentices of the Royal Ordnance Factories is as follows:

Subject	Hours per week — First year	Second year	Third year	Fourth year
Heat, sound, optics	3			
Mathematics	4	3	3	4
Theoretical mechanics	2			
English	1	1		
Mechanical drawing		2	2	
Applied mechanics		2		
Chemistry and metallurgy		2		
Electricity and magnetism			2	
Applied mechanics and heat engines			3	
Electrical engineering				2
Strength of materials and heat engines				4

The examination for the ordinary national certificate in mechanical engineering is given at the end of the third year, and the fifth year's work for the higher certificate may be taken in the evening or in special day classes. Woolwich had 159 such part-time day students in 1927–28; Coventry, an important automotive center, had 390; and the total for England and Wales amounted to 4314.

National Credentials. It is practically hopeless for the British student, however promising, to seek employment or advancement "on his face" alone; he is certain to be asked for his formal credentials; hence the importance of "leaving examinations" attested by some certifying agency of unquestioned authority. The university degree fulfils this function in its own field. In other fields there is a strong movement toward national certification. The English and Scottish Boards of Education, acting in conjunction with the national professional institutions of mechanical engineers, electrical engineers, chemists, naval architects, and gas engineers, have developed in recent years a most satisfactory scheme of examinations and awards. National diplomas are given for successful examinations following full-time day courses and national certificates following part-time courses. These examinations are held only in schools specially approved as regards equipment, staff, and curriculum. The papers are set and the books graded by the local teachers, but in the final year of the senior and of the advanced course the teachers are associated with assessors, appointed by the several professional institutions, who moderate the papers and revise the grading. Credit is given for home work, class work, practical exercises, and attendance, as well as for examination grades. The success of this plan in combining freedom for the teacher, latitude for the school to fit its program to local needs, and the guarantee of a professional body of the highest repute has been notable. There is an active demand for an extension of the plan, particularly in the field of building construction.

Both the national diplomas and the national certificates are awarded in two grades known as "ordinary" and "higher," for senior and advanced courses, respectively. Taking the awards in mechanical engineering as an illustration, the following data for the year 1927 indicate the scope and the working of the plan:

DATA ON NATIONAL DIPLOMAS AND NATIONAL CERTIFICATES IN MECHANICAL ENGINEERING, ENGLAND AND WALES, 1927

Credentials	Schools approved	Schools participating	Candidates examined	Candidates passed	Passed, per cent
Ordinary certificate	108	92	1,150	593	51.5
Higher certificate	52	42	340	239	70.2
Further endorsement		3	17	17	100.0
Ordinary diploma	12	6	42	29	69.0
Higher diploma	7	5	36	31	86.1
			1,689	909	(av.) 53.8

As an indication of relative importance, the number of university degrees in mechanical engineering and mechanical science awarded in the same area and period probably did not exceed 250.

The chief certificating agency for craft and technological branches is the City and Guilds of London Institute, maintained, as its name implies, by the ancient "livery companies" which in medieval times regulated craft apprenticeship. Its examinations are wholly "external," but are set and assessed with the advice of committees representing the respective trades, industries, teachers, and schools concerned. The syllabuses are elaborated in considerable detail and exercise a controlling influence on the teaching of technological and trade branches, particularly in the textile field. Most of the examinations are given in two stages, leading to preliminary and full technological certificates, respectively. The prospectus of the Institute lists 99 separate branches for which certificates are granted, 7 of which are of an engineering character and 26 are various branches of textile technology. In 1927 the Institute gave examinations in 85 subjects at 354 ex-

amination centers; 11,308 candidates were examined and 7051 received passing grades.

General Observations. Success in maintaining both university types of technical education and more intensive types in the same institutions is due to the fact that each has attained to a strong and stable development independently and that each is held true to its function by external controls. In the mixed institutions the day colleges are invariably the smaller in enrolment. The testimony of those best informed indicates that when the situation is dominated by a group of professorial teachers there is a steady drift toward university types and methods. Certain of the London polytechnics, originally created out of charity funds for the education of the working classes, have become through this drift virtual outposts of the University of London, largely attended by students from outside the areas and populations they were designed to serve. In general, however, the influence of the national and local educational authorities, the professional institutions, and the three influential associations representing the technical institutions, the principals, and the teachers, respectively, operates to hold this admirable group of schools true to their social function.

The Higher Industrial Schools of Germany

The German Educational System. The precisely organized

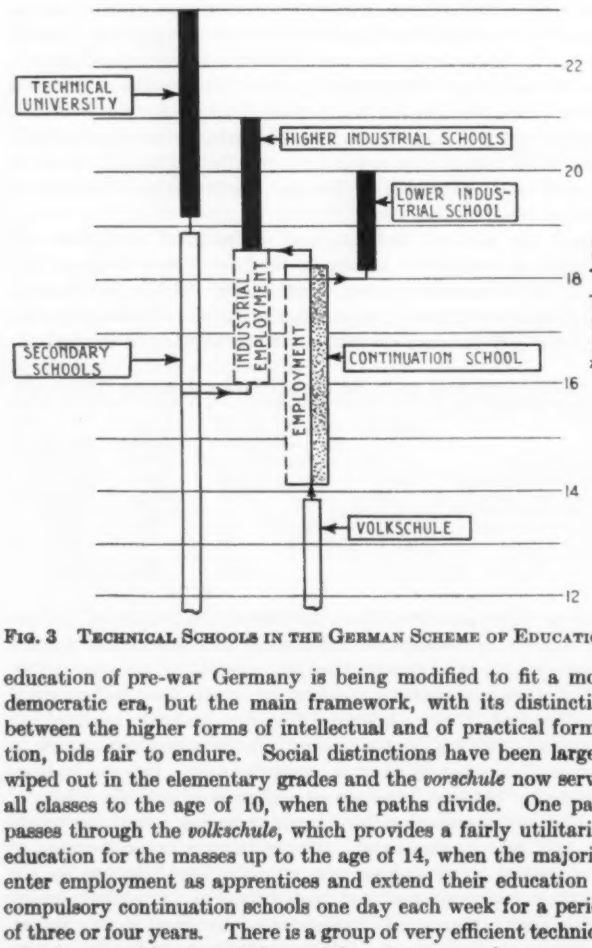


Fig. 3 Technical Schools in the German Scheme of Education

education of pre-war Germany is being modified to fit a more democratic era, but the main framework, with its distinction between the higher forms of intellectual and of practical formation, bids fair to endure. Social distinctions have been largely wiped out in the elementary grades and the *vorschule* now serves all classes to the age of 10, when the paths divide. One path passes through the *volkschule,* which provides a fairly utilitarian education for the masses up to the age of 14, when the majority enter employment as apprentices and extend their education in compulsory continuation schools one day each week for a period of three or four years. There is a group of very efficient technical schools, *maschinenbauschulen,* giving two-year day courses, which the abler apprentices may attend at the end of this four-year continuation period. The other path embraces four parallel types of secondary schools which range from the ultra-classical to the ultra-modern, the higher industrial schools with which we are concerned and the academic and technical universities. (See Fig. 3.)

There is an intermediate terminus point in the secondary curricula which falls at or near the age of 16; in fact, many schools end their work at this stage, or that of the *obersecunda* examination. The higher industrial schools are the principal means of higher education for the young men who leave the secondary schools at this stage to enter technical pursuits.

Character of the Higher Industrial Schools. Schools of this type exist throughout central Europe and Scandinavia under the common name of *technikum.* They are full-time day schools which admit students who have left the secondary schools at 16 and have passed through a probationary period of two years or more of industrial experience directly related to the prospective course of studies. They also receive graduates of the *volkschulen* with four years of experience and continuation schooling who can pass a fairly severe examination in mathematics and physical science. In general, three-quarters of the entering students come from the former source and one-quarter from the latter. There are three important types of schools in this category—*höhere maschinenbauschulen* for the mechanical and electrical industries, *höhere baugewerkeschulen* for architecture and the building industries, and *höhere gewerbeschulen* devoted to specific industries such as textiles, leather, paper, coal mining, and the like. There are between thirty-five and forty such schools in all, mostly under state or municipal control, though a few are under private auspices. Precise statistics are lacking, but the total enrolment appears to be about 12,000.

The private institutions are having a hard struggle for existence, but the public institutions receive fairly generous support and for the most part they are admirably housed, staffed, and equipped. In some cases, as at the school for machine and marine construction at Hamburg, notable additions have been made since the war. In most of the states these schools append to the Ministry of Commerce and Industry, whereas the technical universities append to the Ministry of Education. This separation of control tends to hold each type true to its distinctive function and has apparently made for generosity in appropriations for equipment and current support.

The Maschinenbauschulen. The higher and lower types of schools are seldom combined in a single institution. The lower schools have a four-semester program and the higher schools five. The two teach much the same subjects, but on different levels. The lower schools train draftsmen, inspectors, foremen, and the like, but the higher schools are recognized as engineering schools and their graduates are eligible to join the Verein Deutscher Ingenieure after five years of further experience. There is little migration between these schools and the technical universities, nor does there appear to be much competition between the two groups in the placement of graduates. The *maschinenbauschulen* appear to have less difficulty, as their men are more widely adaptable to the every day needs of industry, especially the needs of the smaller concerns.

There are usually semi-distinct divisions for mechanical and electrical engineering, and in some cases a third division is added in some kindred field such as marine engineering, metallurgy, or fine mechanisms. Typical courses of study from the higher schools are shown in Tables 1 and 2.

The Baugewerkeschulen. These schools resemble the higher mechanical schools in status and operation. The emphasis of the teaching is on design. Modern forms and every-day problems are everywhere emphasized, while classical and gothic forms of construction and ornament receive only incidental consideration. The fact is that these schools have largely created the modern German styles of domestic construction, so homogeneous and yet so free from monotony and commonplaceness. Nine-

TABLE 1 TYPICAL PROGRAM OF HIGHER MACHINE CONSTRUCTION SCHOOL

Mechanical Section

	Semester I	II	III	IV	V
	Hours per week				
Mathematics	10	6	4		
Mechanics	10	10	6		
Chemistry	4				
Projection drawing	6				
Industrial hygiene	2				
Machine drawing and design	10	12	4		
Mechanical technology	2	4	4	4	2
Acoustics and optics		2			
Thermodynamics		2	4		
Laboratory of technical physics			4		
Electrotechnics		4	4	2	
Hoisting and conveying machinery		4	6		
Boilers			4	4	
Steam engines			4	6	
Internal-combustion engines				4	
Steam turbines				4	
Electrotechnical laboratory				2	4
Building construction				2	4
Pumps and water turbines				4	2
Political and social economy				4	6
General options				2	2
Special branches of machine construction					4
Chemical laboratory					2
Autogeneous metalworking					2
Design projects					12
Mechanical laboratory				6	6
Total	44	44	44	44	46

TABLE 2 TYPICAL PROGRAM OF HIGHER MACHINE CONSTRUCTION SCHOOL

Electrical Section

	Semester I	II	III	IV	V
	Hours per week				
Mathematics	10	6	4		
Mechanics	10	8	4		
Chemistry	4				
Projection drawing	6				
Industrial hygiene	2				
Machine drawing and design	10	12			
Electrical technology	2	4	4	4	2
Acoustics and optics		2			
Electrical science		8	6		
Thermodynamics		2			
Electrical measurements		2	4		
Laboratory of technical physics			2		
Building construction			4		
Power machinery			6	6	
Electrical machinery			8	10	12
Electrical communications			2	4	
Social and political economy				4	6
General options				2	2
Electrical installations and layouts				8	4
Laboratory of electrical machinery				4	8
Laboratory of electrical communications				2	4
Special applications of electricity					4
Mechanical laboratory					4
Totals	44	44	44	44	46

tenths of the new construction in Germany is said to be designed and executed by men trained in the *baugewerkeschulen* as architects, engineers, contractors, and superintendents. Much of the instruction is given by project work, dealing with farmsteads, dwellings, schools, apartments, single-span bridges, industrial buildings, and water-power developments of small power and low head. The student is taught from the beginning to think in graphic terms and soon acquires a rapidity and excellence of presentation which amazes an American observer. The laboratory side of the instruction is distinctly meager, being limited to technical exercises in physics, chemistry, and structural materials. Distinct courses of study are given in architecture and engineering construction. An example of this is shown in Table 3.

Common Characteristics. A round of visits to classes and laboratory work heightens the impression of the practical emphasis of the instruction. There are no lecture amphitheaters, as in the universities. Class sections range from 15 to 40, with an average of about 24. Most of the classrooms are fitted with drafting tables. In many schools each section has its own room and each student his permanent table; the section remains in place and teachers come and go according to the schedule, except for the laboratory subjects. Special rooms for chemistry and physics serve as combination classrooms and laboratories. The technical laboratories are distinct installations differing but little from those in American engineering colleges. The laboratory work in physics, chemistry, and mechanics deals with technical mechanisms, instruments, materials, and situations. No attempt is made to teach "pure science." Mathematics, which extends somewhat into calculus, is geometrical in its emphasis and concrete in its teaching materials. Large use is made of structural and machine parts and models. No attempt is made to teach the practical operations of machine or building construction—these must be learned in practice. Practically no instruction is given from textbooks; direct methods are used and the teacher is the primary source.

TABLE 3 TYPICAL PROGRAM OF HIGHER BUILDING CONSTRUCTION SCHOOL

Engineering Section

	Semester I	II	III	IV	V
	Hours per week				
Social and political economy	2	2	2	2	2
Mathematics	10	8	2		
Freehand drawing	2				
Descriptive geometry	6	2			
Mechanics	6	2			
Physics	2	4			
Construction elements, drawing	12	10			
Chemistry and building materials	2	4	2		
Building science	2	2	2		
Hydrology and mineralogy		2			
Machine construction and electrotechnics		2	4	2	
Surveying and plotting		2	2	4	4
Theory of structures		4	4	4	4
Estimates, supervision, and contracts			2	2	2
Excavation and tunneling			4		
Railroads			4	4	4
Hydraulic earthworks			4	2	
Stream, canal, and sluice constructions			2	4	6
Highways and pavements				2	4
Waterworks and distribution				4	4
Basins and harbors				2	4
Irrigation					2
Projects in wood construction			4		
Projects in masonry and concrete construction			4	4	4
Projects in framed structures			2	4	4
Architecture of engineering structures				4	
Totals	44	44	44	44	46

It will be observed from the programs that the working schedules call for forty hours and more per week, making essentially all-day schools where the work is largely done on the premises under supervision. The school year covers ten months. Students are required to attend regularly and perform their work punctually. There is none of the *lern-freiheit* of the universities. Grades and promotion are based on daily performance and semester examinations. A jury appointed by the state, but including representatives of the school staff, gives a comprehensive final examination, partly written and partly based on an inspection of the student's portfolio of exercises and reports. Success in this examination makes the graduate eligible for certain civil-service appointments, but no formal title is conferred.

Teachers. Teaching salaries and titles are on a par with the higher posts in the secondary schools. Appointments are eagerly sought after. The faculty rosters show more doctors, both in engineering and philosophy, than most of the leading American engineering colleges. Taking Hamburg as an example, teachers are appointed only after five years of experience in practice and pass through a probationary stage before receiving permanent status. The salary rises by steps to a maximum of 11,000 marks ($2750) per year, which corresponds in the social scale, though scarcely in the scale of buying power, to roughly twice that sum in America. There is a striking absence of young and inexperienced teachers. The work loads are fairly heavy, averaging about 24 hours per week, plus preparation and correction. The teaching year covers ten months. As a rule there is only a small margin of time for practice, research, or scholarly work, and the production in these forms is distinctly creditable.

General Observations. No real areas of conflict appear to have developed between the technical institutes and the universities.

Each of them accepts its function with pride and works with contentment.

Admission to the institutes is limited and selective, while the universities are open to all who hold a maturity certificate of secondary education. The institutes are always filled to capacity, but never overcrowded, and the student can count on individual attention, which cannot be said of the universities. In the aggregate the technical institutes supply fully half of the technical recruitment of the mechanical industries, more than half that of the building industries, and practically all of the higher personnel in specific branches of technology such as textiles and printing, which are not covered by the universities. The German Committee for Technical Education, a joint representative agency for the professional societies, industries, schools and government ministries, fosters the universities and technical institutes impartially, but exerts its influence to keep their functions distinct.

Conclusions

Interpretation of European Experience. What significance, if any, have these European examples for American technical education? It is well to recognize that the differing educational forms abroad follow planes of social cleavage which we do not wish to reproduce. Their merits, however, stand largely apart from these incidental considerations and may be found to be in no sense incompatible with American ideas of democracy. It is clear that Great Britain, Scandinavia, and the countries of Central Europe expect to recruit a goodly portion of their higher technical personnel from young men who already have passed through a period of normal industrial experience. Quite naturally, these young men aspire to the higher practical posts more often than to highly intellectual functions; their aim is to be men of action rather than men of reflection. The break in their schooling has made them less "book minded" and their industrial experience has accustomed them to direct methods of learning. Also, since their higher schooling represents either an added burden to be carried in addition to employment or an interruption of earning power, they are disposed to work intensively toward predetermined ends.

Moreover, Europe does not expect young men who have devoted themselves almost continuously to social and intellectual pursuits to the age of 22 or more, and have been strongly individualized in the process, to turn eagerly to the highly systematized production side of industry. Nor are we succeeding well in enticing them into it, as evidenced by recent data on the sources of recruitment of the higher technical and supervisory positions of five representative manufacturing industries, as follows:

DISTRIBUTION OF 15,000 COLLEGE MEN ACCORDING TO FUNCTIONS

	Per cent
General officers	9.9
Engineering and technical	33.0
Production	9.0*
Sales	38.1
Miscellaneous	10.0
	100.0

* Lowest

Proposals for American Education. In order to focus further discussion on concrete issues, the conclusions of the study are put into summary form:

1 Democratic ideals are not satisfied by an unlimited expansion of professional technical education of the university type; we need to create a second and parallel educational ladder of more adjustable entrance and terminal levels, to serve men already employed, and to provide higher forms of continuative education beyond the newly developing system of vocational schools.

2 The non-university technical schools for the higher age levels have certain clearly indicated fields of distinctive service, as follows:

a They should largely meet the needs of men who have been or are already employed in industry, who have chosen definite paths of progress, and who desire intensive preparation for advancement

b They should be largely responsible for training supervisors of production and installation, men who will begin in overalls and climb the ladder through foremanship and superintendency to management

c They should largely meet the need for training in the operative technology of specific industries, a type of education that has a very limited place in the professional schools

d They should largely meet the needs peculiar to local populations and local industries, leaving to the universities the more universal aspects of science and technics

e They should provide specific terminal courses of training for technical pursuits and functions which do not actually require four years or more of preparation, such, for example, as surveying, machine and tool design, the design of simpler structures, plant operation, and equipment maintenance

f They should admit their students on evidences of capacity and interest, and only incidentally on formal academic credentials

g Their teaching methods should be adapted to men whose habitual modes of learning are by direct instruction and experience, as in industry

h They should shape their programs as far as practicable on detailed analyses of actual vocational usage.

3 Suitable incentives and forms of recognition are needed to promote and stabilize these more varied and flexible forms of technical education. To this end it is important to establish nationally recognized credentials other than academic degrees. The author strongly commends British practice as represented by the national diplomas and national certificates and by the certificates in technology of the City and Guilds Institute.

4 Large contributions can be made to the ends outlined through evening and extension courses, but the limitations of pace and scope are severe. Data from numerous sources, reinforced by European examples, indicate that the potential field for full-time and part-time day education in technical institutes is at least double and probably treble that properly belonging to technical schools of university rank.

5 European and American experiences alike indicate that professional and intensive forms of technical education cannot be maintained in equilibrium in the same institution, unless each has previously grown to a vigorous state independently and each is held true to its proper function by external controls. In general, it may be stated that different teaching forces are needed for the two types of education.

6 The major responsibility for filling the present gaps appears to rest, first, upon the states, and, second, upon the larger industrial cities. Private institutions have an important place through their freedom to select, to experiment, to specialize, and to strive for superior excellence. It is important, however, to keep the field from being preempted by organizations and institutions which cannot bring to it ample facilities, competent personnel, and assurances of permanent support.

7 In the absence of a national ministry of education, a prime responsibility for the nurture of technical education in well-balanced forms rests on the national organizations of the engineering profession.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

The Most Economical Steam Pressure for Central Stations, Assuming the Use of the Löffler Boiler

THIS extensive paper is a consideration—with special reference to steam pressure—of the economic features determining the first cost and cost of operation of various central-station power plants under European conditions, principally German.

The author, Dr. Friedrich Münzinger, assumes that the station under consideration is large enough to permit the use of all those means of cutting costs which large-scale operation permits. He assumes naturally first-class station design and the use of powdered coal. He leaves out of consideration the cost of the land on which the station is built, largely because this is a factor which is not determined by engineering considerations exclusively and may vary widely for reasons having nothing to do with the station design. He then proceeds to compare various types of central station mainly as affected by the choice of the steam pressure. As the Löffler boiler is already quite extensively used in Austria and Czechoslovakia and is well known to German engineers, he takes it as a representative type of the super-pressure boiler. He assumes that the coal for the entire station would be pulverized in a central pulverizing plant and makes certain allowances for the cost of pulverizers, the scheme of operating the pulverizers, and the relation between the peak load on the plant and the distribution of the load on the pulverizer.

Thermodynamic Factors

Fig. 1 shows the values of heat consumption in large calories per kilowatt-hour as affected by steam pressure, it being assumed that the best turbines of very large capacity and powdered-coal-fired boilers of high efficiency are employed. It is then assumed that the thermodynamic efficiency in the high-pressure stage, i.e., ahead of the interstage superheaters, is about 76 per cent, the efficiency of the lower-pressure stages being determined by the Melan method. Fig. 1 does not therefore refer to turbines of any particular make. Up to pressures of 38 atmos. the turbines are bled twice to provide steam for feedwater preheating, and at higher pressures, three times. It is necessary to select in the most economic manner the corresponding intermediate pressures. The live-steam temperatures employed at the turbine are shown by curve 6 of Fig. 1. Depending on the pressure, in the case of ordinary boilers these temperatures lie between 440 and 480 deg. cent. (824 to 896 deg. fahr.). In the case of the Löffler boiler, however, they are assumed to be 480 deg. cent. (806 deg. fahr.) throughout, because this boiler is so designed as to give a more than usually constant degree of superheat at varying loads. If the pressure is higher than 38 atmos. a simple interstage superheating by condensing live steam is assumed. The author considers next the heat economy in various types of bleeder arrangement as compared with direct expansion of live steam to condenser pressure, etc. Since in the case of live steam at high pressures we have no information as to the influence which the final moisture caused by direct expansion has on the quality of the steam, it is impossible to compare precisely the various arrangements. The saving in heat units by interstage superheating is, however, always greater than indicated by the curves of Figs. 1 and 2, as the thermodynamic efficiencies for the case of direct expansion are there stated very conservatively. According to the curves of Fig. 2, with live steam at pressures of from 100 to 130 atmos. and fresh-water cooling, the saving of heat through bleeding and interstage superheating as compared with direct expansion is about 9.5 per cent. The heat consumption of a turbine at full load (measured at the generator brushes), not including the power consumption of the condensers, is, in the case of fresh-water cooling at about 130 atmos. steam pressure, 2400 kg-cal., which gives a saving as against live-steam pressure of 17 atmos. or about 24.6 per cent. Because of boiler losses and the power consumption of auxiliaries (given in the original paper in Figs. 8 and 9, not reproduced here), the heat consumption measured on the high-pressure side of the plant carrying full load, i.e., the heat consumption in usefully delivered kilowatt-hours, is considerably higher. At 130 atmos. steam pressure and fresh-water cooling it amounts to about 3020 kg-cal. (11,983 B.t.u.) per kw-hr. as shown in curve 5, Fig. 1, so that the saving as against 17 atmos. abs. steam pressure is reduced from 24.6 to 20.6 per cent.

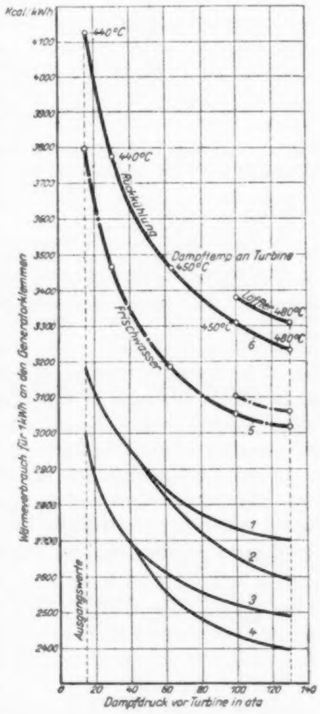


Fig. 1 Heat Consumption per Kilowatt-Hour With Fresh-Water Cooling and Recooling in the Case of Very Large Turbines

(Curves 1 to 5 are for fresh-water cooling: 1—Direct expansion; 2—direct expansion with interstage superheating; 3—direct expansion with bleeding; 4—direct expansion with bleeding and interstage superheating; 5—heat consumption of entire plant at full load, including all losses in power plant; 6—heat consumption at full load by recooling.)

(*Rückkühlung* = recooling; *dampftemp an Turbine* = steam temperature at turbine; *frischwasser* = fresh water; *ausgangswerte* = starting values. Ordinates = heat consumption per kw. at the generator brushes in large calories per kw-hr.; abscissas = steam pressure ahead of the turbine in atmospheres absolute.)

Interstage Superheating

The author points out that interstage superheating with live steam is becoming more and more popular, and disagrees with the views expressed in American publications to the effect that interstage superheating with stack gases is preferable. It is only

from a purely thermodynamic point of view that an advantage may be seen in the fact that by this method, at least theoretically, an unlimited temperature of interstage superheat may be obtained, but even this advantage, such as it is, has to be paid

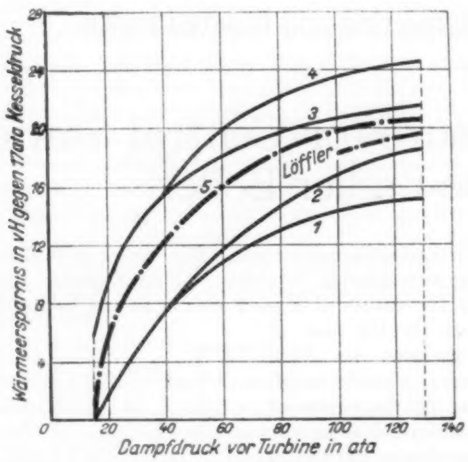


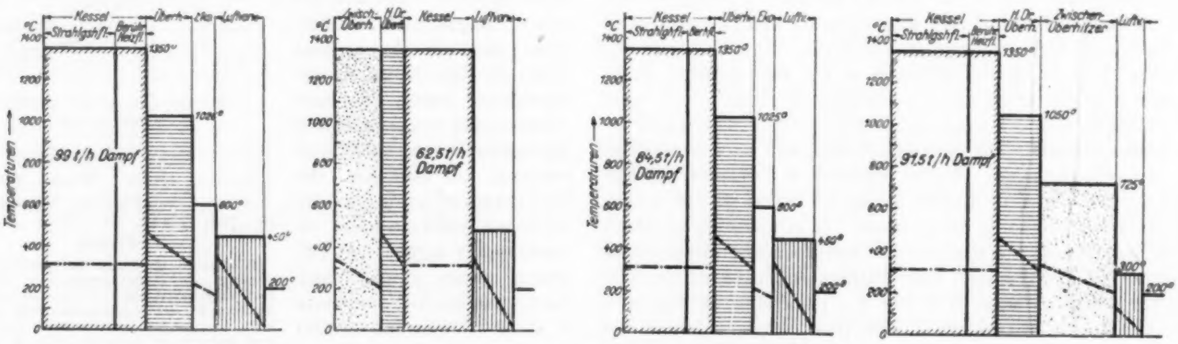
FIG. 2 SAVINGS IN HEAT CONSUMPTION AS COMPARED WITH PLANT OPERATING WITH 17 ATMOS. ABS. BOILER PRESSURE AND FRESH-WATER COOLING

(Saving through:
1—Higher pressure only
2—Direct expansion and interstage superheating
3—Direct expansion and bleeding
4—Direct expansion, bleeding, and interstage superheating
5—Direct expansion, after deducting all losses in the power plant.
Ordinates: Heat saving in percentages as against 17 atmos. abs. boiler pressure; abscissas: steam pressure ahead of turbine in atmospheres absolute.)

for. The design of boilers, for interstage superheating may force us to accept features in the layout of the plant which would better be avoided. The interstage superheaters or live-steam superheaters of such boilers can be designed either as contact or as radiant superheaters, or, finally, as a combination of the two. The dimensions and arrangement of the interstage-superheater boilers are determined by the highest temperature of the stack gases at the point of entry into the hottest part of the superheater surface, or the portion of the live-steam-boiler surface that may be devoted to the interstage superheat work. For the sake of rational design of the central station and lower maintenance, it is desirable to have the dimensions of the combustion chambers of boilers and such details as the temperature of preheated air the same in both types of boilers. Furthermore, the number of interstage superheat boilers must be so selected as to provide the simplest system of connections and piping.

In the layout of the plant considered primarily by the author each turbine is served by a group of three boilers. The best plan is therefore to have present in each group of boilers the required interstage superheater boilers in order to make a complete self-contained unit. The requirement that the combustion chambers and floor space of all boilers shall have the same dimensions points to the condition that the amount of heat taken per boiler should be at least approximately the same in both standard and interstage superheat boilers. The latter also should not operate at an efficiency lower than the other boilers, and the live steam generated in the superheat boilers must, when added to the steam produced by the other boilers, give the amount required by the entire unit. An unusually large number of conditions have therefore to be satisfied, which can be done only by employing a combination of units of a number of different types. As long as the superheater of the interstage superheater unit is built as radiant superheater there is no difficulty in satisfying plan requirements with a single interstage superheat boiler added to two ordinary boilers. An entirely different situation arises, however, when the superheater is built as a purely contact heat-transfer type and definite maximum temperatures of stack gases are prescribed at the entrance to the high-pressure superheater.

In the case under consideration the same output of heat is obtained with an interstage superheat boiler and a high-pressure boiler when the interstage superheat is 350 deg. cent. (662 deg. fahr.) and the combustion air in both kinds of boilers is preheated to 350 deg. cent. (662 deg. fahr.), provided the superheaters in both cases are built as radiant superheaters. On the other hand, if the preheated-air temperature is limited to 200 deg. cent. (392 deg. fahr.) both superheaters may be built as contact-type without having the temperature of the flue gases at the entrance to the high-pressure superheater exceed 1050 deg. cent. (1922 deg. fahr.). Figs. 3 and 4 show the changes in flue-gas temperatures at the entrance to and exit from each of the heating surfaces, as well as the temperatures of the air and water in the two combinations. The scale of abscissas is so selected that the rectangles pertaining to each of the heating surfaces represent the heats taken up by them. The abscissas therefore indicate not the magnitudes of the individual heating surfaces but the amounts of heat transferred through them.



FIGS. 3 AND 4 TEMPERATURE AND HEAT CHARTS FOR INTERSTAGE SUPERHEATING BY STACK GASES

(*Kessel* = boiler; *strahlgshfl.* = radiant superheater; *beruhrheizfl.* = contact-type superheater; *überh.* = superheater; *eko* = economizer; *luftvorm* = air preheater; *zwisch überh.* = interstage superheater; *H.dr. überh.* = high-pressure superheater; *dampf* = steam. Ordinates: temperatures.)

Curves in the original article (Figs. 6—not reproduced here) show for four different live-steam pressures and water cooling the heat and steam consumption per kilowatt-hour with single-stage interstage superheat by live-steam condensation, and likewise the dimensions of heating surfaces for each 1000 kw. of indicated turbine output for various intermediate pressures as a function of the moisture in the steam preheated in the last stage of the turbine. From these curves it would appear, for example,

that if the live steam has a pressure of 129 atmos. gage and a temperature of 480 deg. cent. (896 deg. fahr.) and the intermediate pressure is 15 atmos. abs. with a "limit curve" of 10 deg. cent., then the indicated heat consumption is 2270 kg-cal. (9007 B.t.u.) per kw-hr. The steam consumption is 3.3 kg. (7.26 lb.) per kw-hr. and the necessary heating surfaces amount to 14 sq. m. (150.6 sq. ft.) per 100 kw. of indicated turbine output.

The "limit curve" of 10 deg. cent. means that the working steam is superheated by the heat of evaporation of the heating steam to the extent of 10 deg. cent. (18 deg. fahr.) below the saturation temperature of the latter. The larger this difference the smaller become the necessary heating surfaces, but the more the temperature of the steam superheated between stages lags behind the temperature of the heating steam. This is illustrated by a series of curves in Fig. 7 of the original article. From the curves in Figs. 6 and 7 of the original article (neither of them reproduced in this abstract), the following conclusions may be drawn:

a The indicated steam consumption, including the live steam taken for interstage superheating and for the preheating turbine, does not in itself give a picture of the thermal efficiency of the installation.

b The most favorable indicated heat consumption for a "limit curve" of 10 deg. cent. (18 deg. fahr.) is attained when the intermediate pressure is from about 8 to 10 per cent that of the live-steam pressure. In that case the moisture in the steam in the low-pressure stages is from 5 to 7 per cent.

c With a constant "limit curve" the necessary heating surfaces become noticeably smaller when a greater wetness in the low-pressure stage of the turbine is tolerated.

d Since, however, interstage superheating carried very far ceases to produce economies and at the same time the heating surfaces of the interstage superheater become very great, it is advisable where the pressure of the live steam is high to employ an interstage pressure of from 10 to 12 per cent of the live steam and work with a moisture content ahead of the condenser of from 6 to 8 per cent.

The question may arise whether it is necessary or worth while to superheat still further the interstage steam by a flow of heating steam. This question cannot be answered on the basis of purely thermotechnical considerations and depends on a number of conditions. If it is considered permissible to work with steam at the discharge of the condenser having a moisture content of 7 to 8 per cent, then in the case of live-steam pressure of the order of 100 to 130 atmos., single interstage superheat with live-steam condensation is permissible under the assumption that the turbine carries a live-steam temperature of 450 to 480 deg. cent. (842 to 896 deg. fahr.) and that the designer has a free hand in the selection of the interstage pressures. In such a case it might be possible by choosing proper dimensions of the interstage superheater to reduce the wetness of the steam to less than 6 per cent, in which case, however, the specific heat consumption would exceed its minimum value.

Should, however, the conditions be such that steam temperature of 450 to 480 deg. cent. be held permissible for use in the live-steam superheater but not in the turbine, or should conditions be such that only certain pressures can be used in the low-pressure range, then it may become necessary to superheat still further the interstage steam before admitting it to the turbine, and to do this by passing live steam through a heat exchanger and cooling to about the same extent by which the interstage steam must be additionally superheated. The simplest and most economical arrangement is, however, to deliver directly to the turbine high-pressure steam with the highest possible temperature and carry on interstage superheating by means of a branched-off separate flow of steam which is permitted to condense.

It would appear, therefore, that while from a purely thermal point of view interstage superheating with live-steam condensation is equivalent to superheating by flue gases, it is superior to the latter from the operating point of view and from the point of view of initial costs. The connections are simpler, it is easier to maintain the interstage steam temperature constant, the control of the turbine is simpler, the boiler reserves available are larger, the comparatively long periods necessary to start and stop interstage superheaters heated by flue gases are eliminated, and the interstage superheating can be easily cut out in case of trouble. The greatest advantage of interstage superheating by means of live steam lies, however, in the elimination of the long, large-diameter steam piping necessary for carrying interstage steam to and from the interstage superheater. This is all the more important as at least in large central stations this piping is carried side by side with the high-pressure live steam. In the first place, it is more difficult to lay down and properly arrange long piping of large diameter for moderate steam pressures than the smaller-diameter piping for high pressures, and in the second place small valves on high-pressure lines are easier to keep tight. The heat losses from small-diameter pressure piping are also smaller, which may be of practical importance for plants operating for comparatively short periods. (Friedrich Münzinger in a paper presented at the fourth meeting of the Commission for the Investigation of High-Pressure Steam Plants of the Association of Central Stations in Germany, Mannheim, Feb. 22–23, 1929. Abstract from reprint of Proceedings to be published in a German technical journal at a later date, 23 pp., 26 figs. The part abstracted comprises pp. 1 to 5. Further abstracts will appear if space is available.)

Short Abstracts of the Month

AERONAUTICS

The "Helicogyre"

THIS machine is the invention of V. Isacco, an Italian engineer, and is being built for experimental purposes by the British Air Force authorities. The rotation of the wings is caused not by air forced on them as in the Autogyro, but by propellers driven by engines mounted on the main wings, either in the middle or at the tips thereof.

In the "Helicogyre" sustentation is by two or more wings, individually articulated in all directions to a common hub, turning freely around a practically vertical axle. At the ends of each of these wings are mounted small engines with their airscrews to cause the rotation of the wings in all normal conditions of flight. The gasoline tanks for the small wing engines are fitted inside the wings, each engine having its own tank and feed. The sustaining wings have ailerons acting as elevators on an airplane by changing the incidence of the wings. [Actually they also alter the camber.—Ed.]

It is stated that articulation not only in the direction of lift but also in the direction of drag is necessary to prevent the breaking off of the wings at the point where they join the central hub, and where there are changes of load due to periodic variations in the drag force.

It is claimed that the efficiency of the "Helicogyre" is greater than that of other rotating-wing machines because, owing to the fact that the axis of rotation is vertical, the component perpendicular to the plane of rotation is avoided, and this component, it is claimed, is the cause of the low efficiency of the rotating wing with inclined axis. Calculations (not given in detail) show that

in the "Helicogyre" the ratio of lift to drag is not greatly different (about 5 per cent) from that of the orthodox airplane with the same profile and angle of incidence.

Giving figures of machines of the "Helicogyre" type already built, the paper states that machine No. 1 (French Government) lifted 1875 lb. with 100 hp. of wing engines in spite of the fact that the 50-hp. Anzani engines were in the middle of the wings, and that, therefore, the efficiency of their propellers was not more than 60 per cent.

Machine No. 2, with two wings, each carrying a Bristol "Cherub" of 32 hp., weighed 1320 lb. and rose into the air several times, using only 50 hp. It is estimated that with four wings and four engines a weight of 30 lb. per hp. could easily be lifted, and with improved wing design that an even greater load could easily be lifted.

In the discussion which followed Mr. Wimperis pointed out that it was the invention of the hinged wing which turned the rotating-wing aircraft type into a practical machine by giving the stability which the rigid-blade rotating wing lacked.

Mr. Handley Page pointed out that aerodynamically the rotating-wing machine must be inferior because its wings instead of going in a straight line from point to point travel around in circles. With reference to the engines on the wings, he thought added risk might be introduced. Even the best of engines occasionally shed bits such as spark plugs and even cylinders, and when the engines are traveling around at high speed, as in the "Helicogyre," the consequences might be more serious. In the old days of flying, the rotary engines had to be extremely carefully balanced, he said, and it would seem that here all the old difficulties were coming up again. (*Flight*, vol. 21, no 12/1056, Mar. 21, 1929, pp. 244–245. See also editorial on pp. 227–228, *d*)

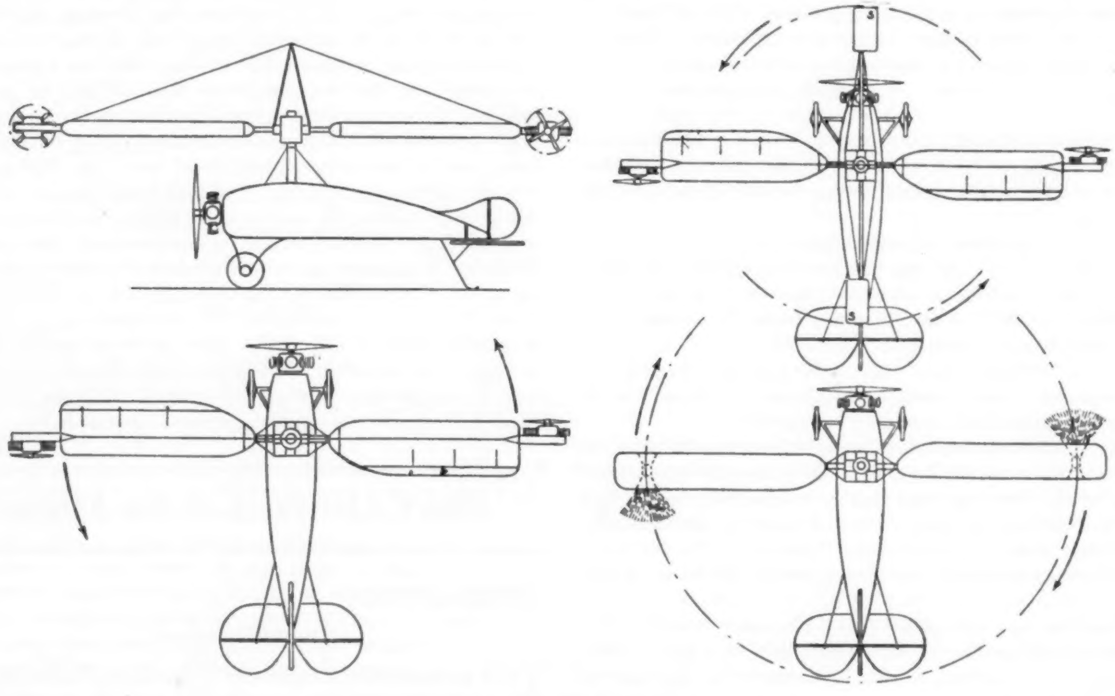


FIG. 1 THE "HELICOGYRE"

(1 shows diagrammatically the general arrangement. In 2 are shown the small control surface *s*, by means of which the machine is controlled when there is no translational speed, i.e., when the machine is hovering. 3 shows Signor Isacco's idea of the jet-propelled "Helicogyre" of the future.)

AIR MACHINERY (See Testing and Measurements: Testing Compressed-Gas Cylinders)

ENGINEERING MATERIALS

French Refractory Hydraulic Cement

PORTLAND cements when heated to a temperature in excess of 500 deg. cent. disintegrate and fall into powder. Magnesia cements set well in the cold and have a greater tenacity. When refractory materials, such as bauxite, were incorporated with them, a good mortar was obtained, but these mortars did not absorb the carbon dioxide from the air and could not stand up against temperatures greater than 800 deg. cent. At these temperatures they became completely friable.

Alumina cements were next investigated. It was found that the cement comprising a mixture of alumina cement and bauxite may be heated to a temperature of approximately 1600 deg. cent. before it will melt. It begins to soften, however, around a temperature of 1350 to 1400 deg. cent. Up to a temperature of 1200 deg. it has a compression strength of 280 lb. per sq. in. When, however, heated to a higher temperature its resistance to compression suddenly drops and becomes about 28 lb. per sq. in. at a temperature of 1300–1350 deg. cent. These cements do not change much when subjected to sudden changes in temperature. Samples taken from a furnace at a temperature of 1380 deg. cent. and brought into a room at 20 deg. cent. do not break or crack. There is a certain friability in these products after they have been heated to a temperature of 1000 deg. cent. This friability, which is probably due to the removal of the water of crystallization, begins to appear at a temperature of 800 deg. cent. and attains its maximum at a temperature between 1000 and 1200 deg. cent., and then disappears altogether at a temperature of 1300 deg. cent.

The friability is generally accompanied by a change in color, and furthermore it is greater the less oxidizing the atmosphere in which the product is heated. In a reducing temperature the color of the cement becomes a clear yellow, while in an oxidizing atmosphere it becomes a yellowish brown.

The cement, or more properly the mixture of aluminous cement and bauxite, is less friable the lower the proportion of bauxite it contains. The mixture of one part of cement and two parts of bauxite, however, never becomes quite so friable that it cannot be used.

Furthermore, the more crushed refractory fragments that the concrete contains, the more friable it is. Hence it is possible to avoid the friability by reducing the proportion of the refractory fragments used as aggregate. Furthermore, it is possible to make the friability of the product disappear altogether by heating the molded article or the piece of concrete for just one time above a temperature of 1250 deg. cent.

Attempts to raise the softening point of the new cement have not met with much success. On the other hand, it has been found that it is possible to diminish and indeed to remove the friability entirely by incorporating with the refractory cement a little pulverized flint or some pulverized sodium silicate. The silicate must be slightly alkaline and not hydroscopic. Flint and sodium silicate, however, have the disadvantage of reducing the fusion point of the cement and the softening temperature.

As regards uses of the cement, the author states that "it must be remembered that the basis of the refractory cement is a hydraulic cement, and hence the mixture can be poured in forms just like ordinary cement. Furthermore, it can be molded by hand or under pressure into objects which are designed to support internal temperatures lower than 1400 deg. cent. The use of these cements removes the necessity of the preliminary heating operation which is necessary in the case of certain refractory materials and which makes them so costly. The pieces of concrete are baked right in their places in the construction of the furnace.

When these cements are employed in the form of concretes, there are many uses which can be found for them. Thus, for example, they may be employed in the construction of furnaces and in the fabrication of specially designed pieces of intricate profile, which are so difficult to secure under ordinary conditions. The cements may thus be employed in the building of chimneys, of baffles, of combustion chambers in producers, for lining the tubes in boilers, and for the flues in recuperative furnaces. In this case the parts are molded under pressure. The cements may also be employed in molding all sorts of parts, such as hearths of all dimensions and sizes, which are furnished with external supports of various kinds. Also there may be mentioned vaulted arch work.

When the cement is employed alone, it can be used to great advantage for repairing broken parts of all sorts, for closing up holes, cracks, and fissures. It can be used as a coating over old constructions of different kinds which it is desirable to protect against the action of high temperatures and flames.

Finally the cements can be admixed with asbestos and then manufactured into boards which are light in weight and which can withstand the high temperatures. (J. Arnould in *Rock Products*, vol. 32, no. 6, Mar. 16, 1929, pp. 57–59, 2 figs., *d*)

Proposed New Criteria of Ductility

IT HAS been assumed in the past according to Unwin that the total elongation is made up of two extensions, namely, a general extension taking place uniformly along the bar before the maximum load is reached and proportional to the gage length, and a local extension occurring after the maximum load has been reached and independent of the gage length. The total length and the original gage length were then connected by an equation with two constants—one for local and the other for general extension. The author, however, in attempting to evaluate Unwin's constants for some typical 10-in. commercial mild-steel test pieces noticed that the elongation was not a linear function of the reciprocal of the gage length. He then tried to determine if possible the law of variation of percentage elongation with size of test piece. Two distinct series of experiments on mild-steel test pieces were carried out. Series 1 consisted of best-quality $1^3/_4$-in. mild-steel shafting, while series 2 consisted of a completely new series of test pieces of ductility entirely different from that of the mild-steel shafting. A comparison of the values of the stresses, the reduction in area, and the hardness for the two different kinds of mild steel tested, revealed that the newly derived constants were almost identical, indicating that by a valuable coincidence the author was examining two steels with properties in common, but which differed in ductility.

The author believes, however, that values of percentage elongation in general are of questionable utility as criteria of ductility. He proposes, therefore, that his new constants (σ = percentage elongation for unit gage length and unit cross-section area, and α = constant for local extension) taken together should be adopted as criteria of ductility.

They possess the important advantages of being: (1) Constant for any given grade of material; (2) practically independent of the type and size of test piece used; (3) indicative of the physical properties of the material, e.g., α is shown to be a function of the internal friction and strain-hardening properties; and (4) derivable from a few extra observations on any of the usual forms of test piece.

General conclusions drawn from the present research and from an analysis of previous work do not seriously vitiate the forms of any of the established standard test pieces. Short maximum lengths do not permit of great accuracy in the determination of α, while specimens greater in length than 5 in. are not only unnecessary but are wasteful of both time of preparation and material. A test piece with 4 or 5 in. maximum gage length and having an area chosen with due regard to the average limits of the slenderness ratios would appear to meet most requirements.

Large forgings weighing tons are sometimes rejected on account of the lowness of the simple elongation figures (taken as evidence of segregation), and thus it would be advantageous if the trustworthiness of this feature of tensile testing could be increased. Thus acceptance of the new constants as reliable criteria is suggested in lieu of the ordinary determination of ductility. Moreover, as σ and α distinguish between the two factors which control the deformation, they should be capable of throwing considerable light on the effects of different heat-treatment processes and on the difficult problems connected with the flow of metals which confront the metallurgist. These criteria should also have distinct value as indications of the perfection of the process to which a sample has been subjected. (D. A. Oliver in a paper before the Institution of Mechanical Engineers; abstracted through *Iron and Coal Trades Review*, vol. 118, no. 3179, Feb. 1, 1929, p. 179, 1 fig., *et*)

MACHINE PARTS

Geneva-Stop Drives

WHILE this type of drive has been known for a long time, it has not found extensive application in the past in the industry partly because of lack of familiarity of designers with this kind of drive and also because of its unpopularity with machine shops, due to the fact that in the past it was difficult to make, and unless made well did not give satisfaction. The cost of manufacture was at best also very high. The author claims that by selection of a proper design and proper proportioning of parts, and, in particular, by the introduction of the involute type of teeth in place of the former grooved type, the cost of manufacture of such gears has been materially reduced

and the specifications brought within the range of easy achievement by the average good machine shop, and at a reasonable price.

The author starts with an analysis of the so-called Maltese-cross drive, which is an intermittent drive. By increasing the number of slots in the drive from a minimum of three (or the common number of four in the ordinary Maltese drive), it is possible to reduce the idle periods to any desired extent, and also to vary the speed of the drive in the different parts of the cycle. It is also possible to vary the speed ratio within a considerable range with the same drive. The author, however, considered chiefly a type of drive in which the same angular speed is maintained throughout the entire revolution.

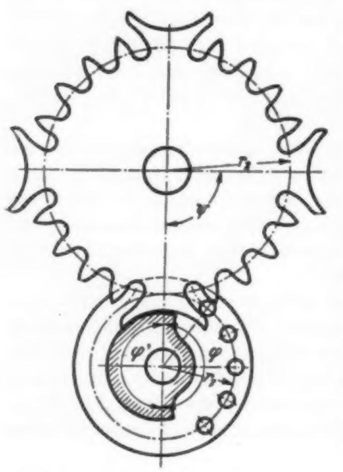


FIG. 2 GENEVA-STOP DRIVE $\left(n = 4;\ \frac{\varphi}{\psi} = \epsilon = 2;\ \frac{t_b}{T} = \frac{\epsilon}{n} = \frac{1}{2}\right)$

THEORETICAL BASES FOR THE DESIGN OF GENEVA-STOP DRIVES

The time period of one run of the gear, which corresponds to one revolution of the driver, consists of

$$t_b + t_r = T \quad \text{[1]}$$

where t_b is the active period and t_r the idle period. If we use instead of the absolute time values the ratios of the different parts of the period to the total run, Equation [1] becomes—

$$\frac{t_b}{T} + \frac{t_r}{T} = 1$$

The equation in this form is more convenient because instead of the various time ratios may be used the corresponding ratios of driver angles. If we denote by φ the angle the driver passes through during one period of motion, and if the cycle is a complete revolution of the driver, the following two equations will be found to hold good:

$$\frac{t_b}{T} = \frac{\varphi}{2\pi} \quad \text{[2]}$$

and

$$\frac{t_r}{T} = 1 - \frac{\varphi}{2\pi} \quad \text{[3]}$$

The purpose of the whole calculation is to determine the ratio of the radii $r_2/r_1 = \mu$. Since, however, there is no direct relation between μ and the values found above, it becomes necessary to introduce a new magnitude ϵ, the ratio of transformation, which means the ratio between the angle of rotation of the driver and the follower during one period of motion. The value of ϵ may be calculated by the following process.

According to the above assumptions

$$\epsilon = \frac{\varphi}{\psi} \quad \text{[4]}$$

But it is found from Equation [2] that $\varphi = 2\pi t_b/T$.

According to the preceding assumptions, however, the corresponding angle of motion of the follower is

$$\psi = \frac{2\pi}{n}$$

where n represents the number of arms on the interrupted gear wheel, assuming a uniform distribution of these arms on the periphery of the gear. If we insert the values of φ and ψ into Equation [4] it will be found that

$$\epsilon = n\frac{t_b}{T} \quad \text{[5]}$$

It would appear, therefore, that ϵ can be determined either from the angles φ and ψ or from the time ratio t_b/T and the number of arms, depending on which of these magnitudes are specified. In other words,

$$\epsilon = \frac{\varphi}{\psi} = n\frac{t_b}{T}$$

If, however, we start from the ratio of transmission as defined above and the number of arms, the time ratio t_b/T can be expressed by the following simple equation:

$$\frac{t_b}{T} = \frac{\epsilon}{n} \quad \text{[6]}$$

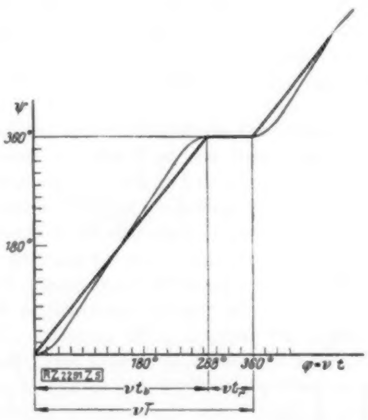


FIG. 3 MOTION DIAGRAM OF A GENEVA STOP

The ratio of transmission ϵ is not equal to the ratio of the radii μ because of the non-uniform motion of the wheel. There is, however, an equation, first proposed by H. Alt, which is as follows:

$$\epsilon = -\mu\left(\frac{n}{2} - 1\right) + n\frac{4 + 3\mu}{\pi}\arcsin\frac{\mu}{2(1 + \mu)}$$

from which by interpolation a table of values for μ can be calculated. This has been actually done and published by Alt himself in *Werkstattstechnik*, vol. 10, 1916, p. 231, and is reproduced with some corrections in the original article here abstracted. What the table in question really gives is a series of values of μ corresponding to the various values of ϵ for different values of n.

LIMITS OF APPLICABILITY OF GENEVA-STOP DRIVES

In Geneva-stop drives the ratio between the idle and active periods may within certain limits be arbitrarily selected. The question is to determine what these limits are. To do this the author uses as a basis the curve of motion of a Geneva-stop

drive, Fig. 3. The abscissas are times, which in the case of a uniformly rotating driver are proportional to the angles of rotation φ. The ordinates are the angles of motion ψ of the follower. The limit will be the situation where the ratio t_b/t_r is still capable of increasing, as when t_r becomes 0, we shall have a case of uninterrupted motion. The theoretical limiting condition is therefore

$$t_b < T \text{ or } \epsilon \leqq n$$

The question now is how closely we can approach to this limit and what the motion then attained will be like. The actual

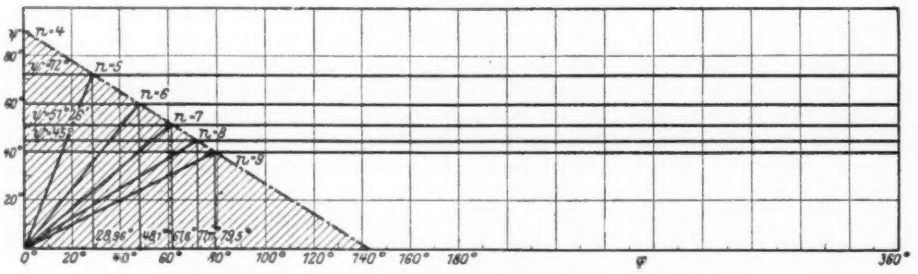


FIG. 4 LIMIT DIAGRAM FOR A GENEVA-STOP DRIVE

representation of motion drawn as a light line in Fig. 3 shows no angles but a gradual passage from rest to motion and vice versa. If we reduce to zero the periods of rest which are already quite short in Fig. 3, the acceleration arc will be found to be directly superimposed on the deceleration arc. This means that at the very instant when one period of motion ends a new period begins. This is actually possible of accomplishment. As soon as the last pin of the group leaves the slot in the follower, the first pin of the next group enters the next slot, so that the follower, after a deceleration up to the rest point, begins immediately to be accelerated. This may possibly prove to be of importance under certain conditions when it is necessary to interrupt a continuous motion for an instant at regular intervals. The other limit of applicability of this kind of gears is attained by increasing the idle periods and reducing the active periods. To a reduction of t_b/t_r corresponds a reduction of the ratio of radii μ, which means that the driver increases in size while the follower becomes smaller; however, the larger the driver the larger the arms, as would appear from Fig. 2. A limit of practicability is finally reached, the arms becoming ultimately so large that there is no more room for them on the small follower and they are forced to extend way beyond it. This difficulty does not arise when the

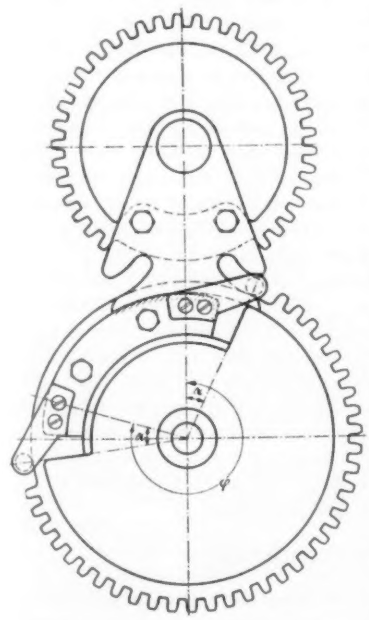


FIG. 5 GENEVA-STOP DRIVE WITH INVOLUTE TEETH

(Given: $t_b/T = 0.80$; $t_r/T = 0.20$; angle of motion $\psi = 360°$; ratio of radii $r_2/r_1 = 41/55$.)

number of arms is not more than four ($\psi \geqq 90$ deg.), but as soon as ψ becomes less than 90 deg. a lower limit of μ becomes operative. This means in practice that the period of motion t_b must not be too short as compared with the entire cycle. The theoretical limit may be seen from the following equation

$$\mu > \frac{2 \sin\left(\frac{\pi}{3}\,\frac{n-4}{2n}\right)}{1 - 2 \sin\left(\frac{\pi}{3}\,\frac{n-4}{2n}\right)}$$

This equation permits drawing a curve of "limit action" for each value of ψ as has been done in Fig. 4. The angular points of this diagram, i.e., the minimum values of φ belonging to each value of angle ψ, are located on a straight line which occupies an otherwise unusable corner of the diagram.

Example. The following practical example is intended to show the method of calculation. The specifications are given by the motion diagram of Fig. 3. The angle of motion $\psi = 360$ deg. so that the number of arms $n = 1$. The periods of motion and rest are in the ratio of four to one, so that the corresponding angles are $\varphi = 288$ deg. and $\varphi' = 72$ deg. The ratio of transmission is $\epsilon = \frac{\varphi}{\psi} = \frac{288 \text{ deg.}}{360 \text{ deg.}} = 0.8$. The ratio of radii is taken from the table above referred to (not reproduced in this abstract) and is $\mu = 0.7455$. If now we select $a = 240$ mm. (9.44 in.) then

$$r_1 = \frac{a}{\mu + 1} = 137.5 \text{ mm.}, \quad r_2 = a - r_1 = 102.5 \text{ mm.}$$

GENEVA-STOP DRIVES WITH INVOLUTE-TYPE TEETH IN PLACE OF SLOTS

It is claimed that by the substitution of involute-type teeth for slots, a simpler and cheaper method of producing Geneva-stop drives can be obtained. The author undertook the investigation of this problem at the instigation of Professor Doctor Alt. The first question was whether it would be possible to introduce involute teeth without changing the whole method of operation of the gear. To answer this question reference may be made to Fig. 2. In the arrangement shown, there is first the starting slot which causes acceleration of movement, as well as the run-off slot which causes retardation. These two slots together with the drive pins are absolutely necessary and have to be retained. As soon as a uniform maximum velocity has been attained, however, it is immaterial what kind of teeth are in mesh. It is only necessary that the teeth properly mesh at the proper time intervals. A solution of this problem is given in Fig. 5. The parts characteristic of the Geneva-stop drive, such as pins, arms, slots, and disks, are entirely separate from the gearing proper and are located to the side thereof. As a result the manufacture of the gearing is easy, and precise location of parts is necessary only during the assembly. The authors shows that with such a built-up gear a very rigid specification can be satisfied. He also shows a method of milling the slots. (Arthur Bock in a paper before the Machine Shop Practice Division of the Verein Deutscher Ingenieure, Sept. 24, 1928, Dresden; abstracted through *Zeitschrift des Vereines deutscher Ingenieure*, vol. 73, no. 12, Mar. 23, 1929, pp. 397–401, 9 figs., *dp*)

MACHINE TOOLS

Drill Bits Faced With Hard Metals

THE drill bits referred to here are those used in well drilling. One of the methods of reinforcing the surface is "stelliting" which means putting a layer of hard alloy called stellite on a softer backing. Another alloy is "stoodite," made by the Stoody Co., of Whittier, Calif. This is a hard chromium-iron alloy with some manganese. It has a hardness between 7 and 8. The same company makes also a material called "borium." This has a hardness between 9 and 10 (will scratch sapphire but not diamond). It is claimed also that it is tough enough to withstand shocks of drilling operations.

A third class of facing material which covers the entire cutting edge and is known as "blackor" has been recently developed by Blackor Co., of Los Angeles. It is a tungsten carbide alloy marketed as black granules which crumble between the fingers and break down in water to a fine, black powder. It does not melt in the acetylene torch and has to be applied with a carbon electric arc. It has a hardness ranging from 8.6 to 9.2, which means about equal to the hardness of sapphire. The Vanadium Alloys Steel Co., of Latrobe, Pa., has conducted tests on lathe tools pointed with borium. (*The Iron Age*, vol. 123, no. 16, April 18, 1929, pp. 1065–1066, 5 figs., *d*)

METALLURGY

Sponge Iron by the Smith Process

THE process described here is an invention of William H. Smith, president of the General Reduction Corporation, Detroit, and formerly chief metallurgical research engineer for the Ford Motor Company. The process consists in the reduction of iron ore or iron oxide materials such as roll scale in vertical ovens at comparatively low temperatures and without fusion.

The ore, crushed to a proper size, usually not over $^1/_4$ in., is mixed with carbonaceous material and charged into the oven, which is of the vertical type. The mixture is preheated in the upper part of the oven by the waste gases which leave the stack at about 400 deg. fahr. Then it enters the reduction zone where temperatures range from about 1600 to 2000 deg. fahr., and after reduction the charge is cooled by the incoming air.

One factor leading to the success of the process is the ability to apply unlimited amounts of heat at 1500 to 2000 deg. fahr., just where needed for the reduction reaction, without affecting the rest of the apparatus. Also precise and automatic regulation can be employed as to quantity and duration of heat in the various zones, more particularly the reduction zone. The ovens are 10 in. wide, 16 ft. 6 in. high, and 20 ft. long. Standard steel sections and firebrick shapes have been used in construction, and special materials for good heat interchange between the cooling and heating flues and the charge. For instance, carborundum is being used in the reduction zone.

Non-coking and brown coals are suitable for the process. The reduction of iron oxides to metal is 100 per cent, and if time is given the reduced iron will absorb carbon up to about 1.8 per cent. Sponge iron is already used as a precipitating agent in the metallurgy of copper, lead, and silver. The product of the present process, it is said, can be used as raw material for making steel and iron, and imported Swedish sponge iron is already so used. The statement is made that it provides a high-grade product as a supplement to the present pig iron with less initial plant cost and much less heat consumption and loss than the modern blast furnace. It is also stated, however, that it may be looked upon as of direct assistance to the blast furnace. It is economical in small units and may be installed in plants or in countries and locations where a blast furnace cannot be employed. (Dr. Geo. B. Waterhouse, Professor of Metallurgy, Massachusetts Institute of Technology, in *The Iron Age*, vol. 123, no. 17, Apr. 25, 1929, pp. 1143–1145, 4 figs., *d*)

MOTOR-CAR ENGINEERING

A Six-Wheel Steam Bus

THIS bus is built in a semi-commercial way by the Automotive Syndicate, Ltd., of Indianapolis, and is intended to carry forty passengers.

The Electro-Steam Coach, termed thus because of the special electric control for the steam power plant, has a single frame for chassis and body. An eight-cylinder 150-hp. engine of the poppet-valve type is located amidships under the floor, with a tandem drive to underslung worms on the two rear axles. Two boilers are mounted at the rear, each discharging its burnt gases above the roof through stacks placed in the rear corners of the body. The flask-type generators are rated at 100 lb. pressure and supply steam superheated up to about 800 deg. fahr. to the main engine and also to an 18-hp. auxiliary power unit. The amount of water injected into the tubes is automatically controlled; when the flow ceases the fire is extinguished, to be ignited again by a spark plug when the flow is resumed. A motor-driven blower is used to force the flame downward around the boiler tubes. The small steam engine which is placed under the floor to the right of the driver's position has the job of driving the 32-volt electric generator, the compressor for the Westinghouse air brakes, and through a V-belt the pump for the boiler feedwater. The main condensers are located at the front under the dash. An auxiliary condenser is mounted flat on the roof of the vehicle, the water being carried to it through passages in the enlarged window posts on each side. A 60-gal. fuel tank and tanks to carry the 70-gal. water supply are also mounted under the floor.

Control is by means of a throttle lever placed under the steering wheel; this is supplemented by a hand lever to the right of the driver, arranged to cut off steam at 15, 30, and 70 per cent of piston travel. The same lever is used for reversing the direction of vehicle movement. The driver has plenty of information for his guidance, although most of the instruments are to be found on the bus of the conventional type, when fitted with air brakes, air control of doors, and switches for dome lights and other parts of the electrical system. Distance is measured by an odometer on the left front wheel, and speed by an electric tachometer with a dash dial indicating miles per hour.

Performance to date indicates that consumption of the furnace oil used for fuel is of the order of 3 miles to the gallon, and that the water supply is sufficient for a 300-mile run. Speeds up to 50 m.p.h. are possible, and about half that with one boiler functioning. Only seven seconds are required to make 25 m.p.h. from a standstill. This is exceeded only by the very high-priced and high-powered passenger automobiles. The complete vehicle weighs about 22,000 lb. The weight is so evenly distributed that wheel loads are alike within 50 lb. (*Bus Transportation*, vol. 8, no. 3, March, 1929, pp. 166–167, illustrated, *d*)

POWER-PLANT ENGINEERING

Centrifugal-Pump Sets for Very High-Pressure Boilers

THE present article deals with an installation diagrammatically shown in Fig. 6 and employing two boilers working at 100 atmos. pressure. Each of the boilers is capable of evaporating 60 metric tons (1 metric ton = 2200 lb.) per hour, equivalent to an electrical output of about 12,200 kw. This is done through a 7000-kw. regeneration-type turbine, an ordinary turbine of 4500 kw. working at 100/20 atmos. gage pressure, and a preheater turbine of 700 kw.

The feedwater is handled by four super-pressure boiler-feed pumps each having an output of 90 tons per hour. Of these two are directly connected with an 18-atmos.-pressure steam turbine, and the other two are driven through a step-up gear by an alternating-current motor. As shown in Fig. 6, the steam is expanded from 100 to 20 atmos. in turbine *a* and goes then through two intermediary superheaters *b* into the main turbine *c* operating

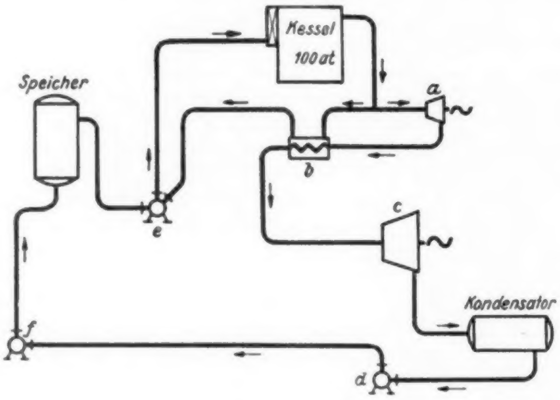


FIG. 6 GENERAL LAYOUT OF PLANT WITH BOILERS, TURBINES, AND PUMPS

(*Kessel*, boiler; *Speiser*, heat accumulator; *Condensator*, condenser; *a*, present turbine; *b*, intermediary superheater; *c*, main turbine; *d*, 2-stage condenser pump; *e*, 9-stage super-pressure boiler-feedwater pump; *f*, intermediary feedwater pumps.)

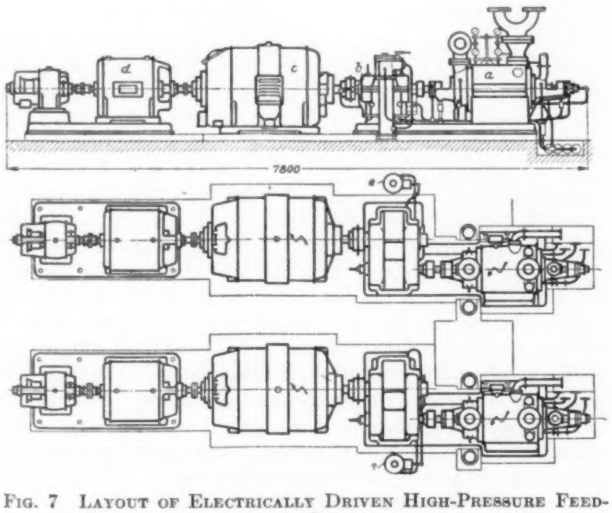


FIG. 7 LAYOUT OF ELECTRICALLY DRIVEN HIGH-PRESSURE FEED-WATER PUMPS

(*a*, 93-atmos. pressure boiler-feedwater pump; *b*, reduction drive; *c*, Scherbius motor; *d*, frequency converter; *e*, oil cooler.)

condensing. In designing the boiler-feedwater layout of the new plant a particular effort was made to utilize the advantages of high feedwater temperature. The water of condensation is taken from the condenser by a two-stage pump *d*, Fig. 6, connected with the cooling-water and the injection-water set, and is delivered together with make-up water to the intermediary feed pumps *f* at a temperature of about 80 deg. cent. These intermediary feed-water pumps, of which there are four, are four-stage Sulzer units having a capacity of 125 tons per hour at a manometric delivery head equivalent to a pressure of 25 atmos, and are driven directly by 2900-r.p.m. alternating-current motors having a capacity of 180 hp. These intermediary pumps deliver the water into a constant-pressure accumulator unit in which water is brought up to nearly evaporator temperature. From this accumulator unit it goes with a temperature of about 200 deg. cent. and a pressure of 18.5 atmos. to the nine-stage "super-pressure" feedwater pumps *e*, Fig. 7, each rated at 90 tons per hour normal capacity at 93.2 atmos. pressure (equivalent to a 1080-meter column of water). There is therefore a pressure of 111.7 atmos. at the end of the ninth stage, and it is with this pressure that the water reaches the 100-atmos. boiler after passing through the economizer. The duty of the intermediary superheater *b*, Fig. 6, is to bring the exhaust steam from turbine *a* having a pressure of 20 atmos. and 250 deg. cent. to a point where its superheat is about 340 deg. cent., and it is only then that it can be admitted into the main turbine. To accomplish this live steam of 100 atmos. pressure and 460 deg. cent. is led through the intermediary superheater in contact with the tubes carrying steam at 20 atmos. pressure. Because of the exchange of heat that takes place here, the temperature of the live steam sinks to a point where condensation takes place at a temperature of something like 306 deg. cent. and an evaporation or saturation pressure of 93 atmos. This water of condensation has to be returned to the boiler and is therefore led into the super-pressure feedwater pumps with a pressure of 82.5 atmos. and a temperature of 297 deg. cent. so that as little pressure as possible shall be lost. The condensate is admitted into the pump through

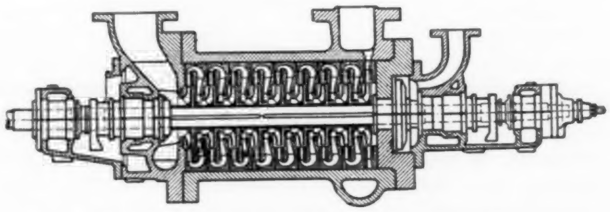


FIG. 8 SECTION THROUGH THE SULZER SUPER-PRESSURE CENTRIFUGAL PUMP

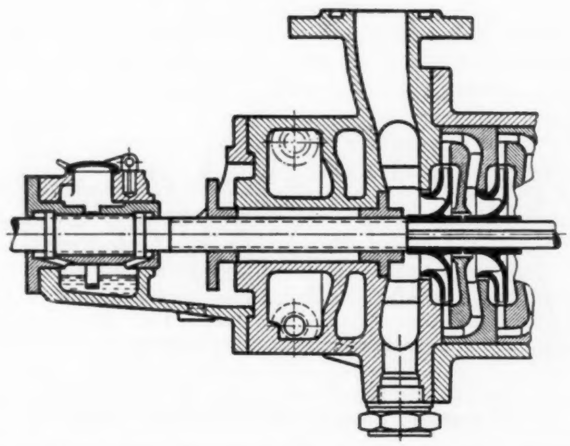


FIG. 9 HOT-WATER STUFFING BOX WITH EXTERNAL COOLING, TYPE USED IN 1923

an auxiliary connection which for the above reasons is set behind the sixth stage of the pump.

In operating centrifugal pumps it is preferable to control the output by varying the speed of rotation rather than by throttling, and the former method is used with electrically driven pump sets. To do this the driving motors have been wound as Scherbius motors, and equipped with frequency converters and Askania governors. It was impossible to couple the pumps directly to the electric motors as that would have made the number of stages of the pumps excessive. To avoid this the pumps are driven through gear-reducing units having a ratio of 1470 to 4650 r.p.m.

Fig. 8 shows in section the Sulzer nine-stage super-pressure pump. In order to eliminate certain difficulties, new methods of design had to be resorted to in some particulars. First of all, particular attention has been paid to the matter of eliminating heat stresses. Contrary to the usual practice, the pumps do not stand on legs but are horizontally suspended. This eliminates the variations of height (due to heat expansion) with reference to the foundation. The housing is free to move along the longitudinal axis of the pump. By means of a selection of appropriate materials uniform longitudinal expansions in the running gear

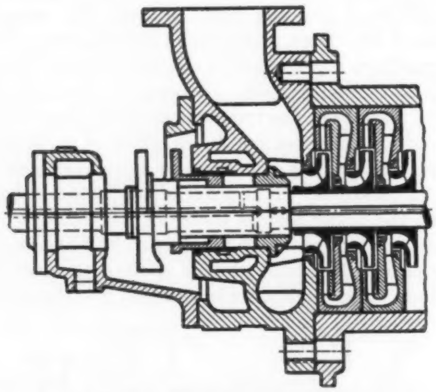


FIG. 10 STUFFING BOX WITH MODERN INTERNAL COOLING

and shaft have been attained. The runners are made of monel metal, the shafts of V. A. M. steel, and the guide wheels of steel castings. In order to balance elastically the last trace of differences due to longitudinal expansion, extension members with ability to give have been built in, while in order to keep heat losses low the pump housings have been heat-insulated. In the stuffing boxes water at 200 deg. cent. and 18.5 atmos. makes it necessary to use packing that will prevent leaks into free air, as otherwise the leak of hot water will produce lively steam formation. Because of this it becomes necessary to thoroughly cool

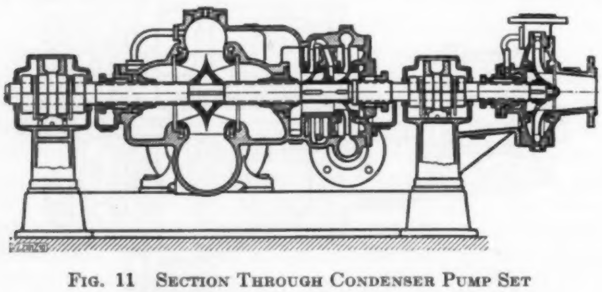


FIG. 11 SECTION THROUGH CONDENSER PUMP SET
(The condensate pump on the right is a 2-stage machine.)

the water which flows through the stuffing boxes. The older method shown in Fig. 9 employed external cooling, but in the 100-atmos. pressure pumps the more modern method of internal cooling shown in Fig. 10 has been employed. In order to reduce heat losses as much as possible, cooling has been restricted to a minimum. It is only at the running parts of the stuffing boxes that internal and external cooling have been resorted to in order to decrease the temperature of such water as may leak out. The cooling water is injected in a jet into the surrounding cooling water space through a bore in the shaft, and is led away from there over the packing through a port in the stuffing box.

To make the packing still better, a water trap has been provided supplied with water at 80 deg. cent. and 20 atmos. pressure from the intermediary feedwater pumps. This water-trap liquid is led from the double stuffing box into the internal space, and because of its high pressure forms a comparatively cold ring of water, with the result that the hot water from the suction chamber of the pump is well shut off by this packing. It flows away then in a uniform stream over the outer space between the two stuffing-box chambers and goes into the condenser collector. As a result the heat taken up by the water trap is not lost, and at the same time all formation of steam in the stuffing boxes is avoided.

As the plant has been in operation only a few months, there are no reliable figures regarding the performance of the pumps. One thing has been completely proved, however, and that is that centrifugal pumps can be used to advantage even for very high pressures. For very small amounts of water, however, the reciprocating pump is superior under certain conditions, as in that case the efficiency of the centrifugal pump becomes too low.

Auxiliary Condenser Pumps. Two interconnected sets of pumps have been provided in the condenser basement for the new 20,000-kw. turbine with 20 atmos. pressure and receiving live steam either from the intermediary superheater *b*. Fig. 6, or from the old boiler plant. Each of these condenser groups consists of a cooling-water pump, a jet-water jump, and a condensate pump. They are driven through a gearing by a steam turbine or through a 300-hp. alternating-current motor running at 735 r.p.m. Both sets of pumps work at that speed, and one set can help out the other. The cooling-water pump which occupies most of the floor space handles the water for cooling the condenser, and is so arranged that the stream of water has to overcome only the resistances in piping and condenser. Approximately 4000 cu. m. (141,258 cu. ft.) of water per hour has to be handled against a head of 7 m. (22.9 ft.), and one pump rotor is capable of doing it. The jet-water pump is shown to the right hand of the cooling-water pump in Fig. 11. It is used to remove the air from the condenser and generates the head necessary for the jet action, namely, 47 m. (154.1 ft.) at an output of 355 cu. m. (12,536 cu. ft.) per hour in two stages. The cooling-water pump and the jet-water pump are located in the same horizontally divided housing. The casting of these pieces requires years of previous foundry experience. The pump handling condensate is located horizontally, outboard, on the end of the shaft beyond the second main bearing. This pump takes by suction the condensate coming from the condenser and forces it over the feedwater collector into the intermediary feedwater pumps shown in Fig. 6. The high vacuum together with the small net supply head makes it necessary to have the stuffing boxes particularly well made and to employ a rotor of great suction power. Water under pressure is used to make tight the stuffing box, this water being taken from the second rotor. A water trap is also used between the two packings and the double stuffing boxes. For this water trap is used condensate which is held in storage for this purpose in a small container 10 m. (32.8 ft.) above the pump. (H. Kissinger in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 73, no. 12, March 23, 1929, pp. 393–396, *dA*)

PUMPS (See Power-Plant Engineering: Centrifugal-Pump Sets for Very High-Pressure Boilers)

SPECIAL MACHINERY

The Knox-O'Neill Vacuum-Process Bottle-Making Machine

THIS new machine is in regular operation for purposes of demonstration at the plant of the Knox Glass Bottle Co. The author of the article who watched the machine in operation comments particularly on its ease and simplicity of operation. The machine now in operation has six blank molds and six blow

molds. The blank molds are arranged on one of two revolving tables and the blow molds on the other. The tables are in mesh and on the same horizontal level.

The blank molds, passing to the forehearth to get a "drink" of glass, open as they approach the opening in the tank. The molds close and dip down and the vacuum sucks up the glass. Immediately after the glass is sucked up the molds pass over a permanent shearing device which cuts off the glass adhering to the bottom opening of the molds. A guard is placed behind each mold to catch any further waste glass.

The molds then pass half way around the blank mold table and come into contact with the blow molds. As they pass this short distance, the mold opens and the blank can be seen hanging. Also in this short movement an attachment on the blank mold comes down and forms the neck and opening of the bottle. It might be added here that the bottle is made erect throughout. As the blank and blow molds come into synchronized position, an arm reaches out from the blow molds and takes a blank with the neck already formed and transfers it to the blow mold. The blow mold closes and the mold passes three-quarters of the way around its circumference, when the mold opens and the bottle falls into a chute which carries it through an inspection station, whence the bottle is carried to the annealing lehr.

Mechanically, the action of the Knox-O'Neill vacuum process was without a hitch. A vacuum pump is attached to the machine and this insures adequate suction as the molds pass through the forehearth opening in the tank. As placed, the machine is at the right front side of the tank. Movement of the machine is effected by an electric motor of 3 hp. It is claimed, however, that $1^1/_2$ hp. would be sufficient.

The machine can take the metal from any tank equipped with a forehearth. The advantages claimed for it are that it does away with the feed device because it uses vacuum suction for pulling the glass from the tank. It is also claimed that because of this, each mold will get the proper amount of glass required, and no more. It can operate with three or more stations while the others are idle. This provides a considerable increase of flexibility as compared with other machines. It is also claimed that a stronger bottle is made and that devitrification of the glass is avoided. (J. M. Hammer in *American Glass Review*, vol. 48, no. 25, Mar. 23, 1929, pp. 15–17, 1 fig., *d*)

STEAM ENGINEERING (See Motor-Car Engineering: A Six-Wheel Steam Bus)

TESTING AND MEASUREMENT

Testing Compressed-Gas Cylinders

PRACTICALLY all the cylinders discussed have been made under Interstate Commerce Commission regulations. The principal features are as follows:

Every new cylinder must withstand a test pressure equal to $1^2/_3$ times the charging pressure at 70 deg. fahr., with a permanent expansion not greater than 10 per cent of the total, and without any previous pressure greater than one-third of the test pressure having been applied. In addition, one cylinder from each 200 must stand a crushing test to six times the wall thickness without cracking. Tensile-test specimens from this cylinder must show an elongation of not less than 10 per cent in 8 in., with an elastic limit less than 70 per cent of the ultimate strength.

The hydraulic test does not give any information regarding the value of the stresses in the wall.

To develop additional tests which would give more information with regard to each cylinder made without harming it, a number of cylinders were studied up to large overpressures. Subsequently the cylinders were burst under hydraulic pressure, tensile-test specimens were cut from their walls, the hardness of the steel was determined, and, finally, the microstructure was studied.

When this work was completed it was found that the curves showing the relation between pressure and volume told a great deal. These curves turned out to be practically straight lines up to the elastic limit (or the point at which permanent expansion takes place). Beyond this pressure the curves are of different shape, depending upon the hardness of the steel. Curves for the softer cylinders act in an elastic manner until a higher pressure is reached, and have a more gradual expansion after it has been passed. The slope of the straight part of the curve indicates the average wall thickness of the cylinder, because a thinner wall will show a greater elastic expansion at a given pressure than a heavier cylinder.

While such curves give a complete story regarding both the wall thickness and the condition of the steel, the determinations are tedious and impracticable for commercial-acceptance work. Fortunately, since the wall thickness is indicated by the slope of the straight part of the curve, a single determination may be used; it was found convenient to use 2500 lb. per sq. in. for oxygen cylinders (commercially charged with 220 cu. ft. of oxygen compressed to 2015 lb. at 70 deg. fahr.) A cylinder having the thinnest wall acceptable would have an elastic expansion at this pressure of 127 cc. Any cylinder too thin would give a larger expansion than 127 cc. at 2500 lb. per sq. in. pressure and would be rejected.

The author next discusses the question of elastic limit as shown by pressure-expansion curves and claims that by means of these curves a complete specification for a hydraulic acceptance test on 220-cu. ft. oxygen cylinders can be stated as follows: At 2500 lb. per sq. in. the elastic expansion must be not greater than 127 cc., and the total expansion must reach a value of 220 cc. between the pressures of 3360 and 4000 lb. per sq. in.

Such a test can easily be made by setting the pressure at 2500 lb. per sq. in. and reading the elastic expansion; if it does not exceed 127 cc. the wall thickness of the cylinder is satisfactory. The pressure can then gradually rise until the expansion reaches 220 cc.; if this point is reached between 3360 and 4000 lb. it is then known that the steel in that cylinder has satisfactory ductility.

Such a test does not, however, conform exactly to the present regulations of the Interstate Commerce Commission.

To obtain further information on the question whether it is right to increase the allowable permanent expansion limit to 25 per cent of the total at test pressure, the expansion of several cylinders was measured up to the bursting point. It was found that even a maximum permanent expansion of 50 cc. is a negligible percentage of the permanent expansion available even in the less ductile cylinders. Incidentally a machine has been developed which automatically draws the characteristic curves for each cylinder. Attempts were also made to determine what happens to a cylinder after it is placed in service. The test is mainly intended to cover the detection of excessive corrosion. (Glen D. Bagley in a paper before the Compressed Gas Manufacturers' Association; abstracted through *The Iron Age*, vol. 123, no. 16, Apr. 18, 1929, pp. 1067–1069, 4 figs., *d*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Engineering and Industrial Standardization

Stock Sizes, Shapes, and Lengths of Hot- and Cold-Finished Iron and Steel Bars

THE A.S.M.E. has accepted sole sponsorship for the standardization of Stock Sizes, Shapes, and Lengths for Hot- and Cold-Finished Iron and Steel Bars and has issued invitations to forty national organizations requesting them to appoint official representatives on the Sectional Committee which will develop this Standard. The scope of this project as set by the American Standards Association is as follows:

Rounds, squares, triangular sections, hexagons, octagons, half-rounds, square-edge flats, nut-steel flats, bevel-cornered squares, round-cornered squares, and including tolerances on cross-sectional dimensions of such bars to the extent that nationally recognized standards are therefore not available.

Standardization in the Printing Trade[1]

THE New York *Times* of April 13 reports that the World Conference of Master Printers meeting in London decided to establish an International Standardization Bureau to obtain international cooperation in simplification and standardization in the printing trade. Although it was felt, according to the report, that it might be impossible to formulate international standards for such things as machines and processes, where established customs would militate against standardization, the advantages of the international adoption of such schemes as the "hypothenuse" method of proportioning the size of paper were stressed. (This is the planned and coordinated system that has already been widely adopted in almost all countries of Continental Europe.) Variations in the thickness of electrotypes, stereotypes, and halftone blocks were found to cause much waste in time and expense. A definite standard, international if possible for all plates would be of great benefit to the trade. It is expected that the bureau will be opened in London temporarily with a capital of $6000.

Roumanian National Standardizing Body[1]

ROUMANIA is the latest country to join the ranks of those having national standardizing bodies. The Roumanian body, which will be known as the *Commission Roumaine de Normalisation*, was recently organized by the Roumanian Institute of Scientific Management, and it will be financed by a special fund included in the budget of the Institute.

The objects of the Commission are, according to its constitution:

1 To simplify economic activity and consequently lower the cost of production through study, application, and development of standardization in Roumania. To this effect the Roumanian body will seek to establish a national technical vocabulary; to establish purchase specifications for different institutions; and to achieve simplification of materials, manufactured products, and machine parts;

2 To coordinate the organizations in Roumania which are interested in standardization, and to represent them before the public and private institutions in the country;

3 To be the representative organ of the Roumanian standardization movement in the relations with similar institutions, with foreign countries, and with international institutions.

[1] From the Sustaining Members' Bulletin of the American Standards Association, 29 West 39th Street, New York, N. Y.

The membership of the main committee of the Roumanian body consists of delegates from the following groups of institutions: Public institutions; technical schools; chambers of commerce, industry, and agriculture; technical and professional associations; trade associations; and institutions or associations whose activities are related to those of the national body.

The Commission will regularly exchange information with the 20 other national standardizing bodies.

Safety Code Correlating Committee Elects Officers for 1929

A MEETING of the Safety Code Correlating Committee was held in the rooms of the A.S.M.E. on April 17, 1929, and a large majority of its 25 members were present in person or represented by their alternates. One of the first items of business on the agenda was the election of officers and the Executive Committee for 1929. The Nominating Committee which had been appointed previous to the meeting presented a report and its nominations were unanimously accepted, thus electing the following-named gentlemen as the Executive Committee for the new year: Messrs. D. Van Schaack, Chairman; L. W. Hatch, 1st Vice-Chairman; John Price Jackson, 2nd Vice-Chairman, L. F. Adams, L. W. Chaney, M. G. Lloyd, and W. Dean Keefer.

After a spirited discussion participated in by all present, the Committee adopted the following resolution relative to its future work as a body advisory to the American Standards Association. During this discussion many of the Committee members pointed out the need for correlating and cross-referencing the existing A.S.A. and state codes and insurance schedules. Others emphasized the importance of a more aggressive educational program on the part of the Committee in its relations with the state officials and managers of industry. The resolution reads as follows:

Resolved: That the safety code activities of the American Standards Association and of the Safety Code Correlating Committee should be consistently directed to the following ends: (1) Direct use of codes by industry; (2) use in insurance schedules and by insurance inspectors in advice to industry; and (3) their use as sound standards for the guidance of those responsible for regulation.

In the spirit of this resolution the Committee then adopted the following memorandum which had been suggested by Chairman Van Schaack, thus creating two new sub-committees:

a The Executive Committee of the S.C.C.C. should stimulate the development of projects lagging in preparation, consider the priority of work, and, as in the past, continue general direction of the work, acting ad interim for the S.C.C.C. and functioning on the approval of personnels, etc., for the A.S.A.

b Sub-Committee on Scope should study the scope and provisions of codes—whether completed, in preparation, or proposed—in their relations to other codes, and take an advisory hand in correlating them for publication in such a way as to make them more readily useful.

c Sub-Committee on Promotion of Codes in Industry should work along definite, selected lines for the promotion and adoption of codes.

The following recommendation was adopted:

The systematic and correlated development of the many projects included in the safety-code program requires supervision by some central agency and can best be carried out by the assignment of at least one man in the office of the American Standards Association who shall devote his entire time to the work.

The Committee then received reports of progress on the various safety codes on which Sectional Committees are now at work, and discussed several new projects.

The Conference Table

THIS Department is intended to afford individual members of the Society an opportunity to exchange experience and information with other members. It is to be understood, however, that questions which should properly be referred to a consulting engineer will not be handled in this department.

Inquiries will be welcomed at Society headquarters, where they will be referred to representatives of the various Professional Divisions of the Society for consideration. Replies are solicited from all members having experience with the questions indicated. Replies should be as brief as possible. Among those who have consented to assist in this work are the following:

ARCHIBALD BLACK, Aeronautic Division
A. L. KIMBALL, JR., Applied Mechanics Division
H. W. BROOKS, Fuels Division
R. L. DAUGHERTY, Hydraulic Division
WM. W. MACON, Iron and Steel Division
JAMES A. HALL, Machine-Shop Practice Division
CHARLES W. BEESE, Management Division
G. E. HAGEMANN, Materials Handling Division
J. L. WALSH, National Defense Division
L. H. MORRISON, Oil and Gas Power Division
W. R. ECKERT, Petroleum Division
F. M. GIBSON and W. M. KEENAN, Power Division
WINFIELD S. HUSON, Printing Industries Division
MARION B. RICHARDSON, Railroad Division
JAMES W. COX, JR. Textile Division
WM. BRAID WHITE, Wood Industries Division

Fuels

Boiler-Tube Failures

F-7 What specific instances can be quoted when using distilled-water make-up, of the blistering or failure of boiler tubes directly exposed to the radiant heat of the furnace? Instances are desired either on the first two rows of boiler tubes, on the water walls, or on water screens, either with stoker, pulverized-fuel, or oil firing. Quote circumstances and method of eventual solution.

To the writer's knowledge there have been no instances where, when using distilled feedwater, boiler tubes have blistered due to their exposure to radiant heat of the furnace where the circulation was not impaired by obstruction in the boiler tubes or where there had been no direct impingement of intensely hot flames from oil or gas burners.

On horizontal water screens with pulverized-coal firing, incipient blistering is not uncommon. These blisters invariably occur on the top side of the tube, and the reason is obvious.

There have been a few instances of blistering of vertical water walls with all types of firing. Aside from those cases for which scale formation is responsible, there have been several instances of blistering due to faulty circulation, combined usually with extremely high absorption rates.

In a number of inclined-tube water walls in which slightly inclined tubes connect two vertical headers at opposite ends, the circulation is so faulty that the tubes will invariably burn or blister at high absorption rates. Vertical tubes are not likely to blister unless the circulation is inadequate or, as in one known instance, where the lower portion is protected by refractory, leaving only a few feet of the upper end exposed to the furnace.

In some instances the difficulties would be laid to selective circulation. The inclined side-wall tube is a typical example of this condition. The solution lies in the provision of ample areas for risers and downcomers and, in the case of the inclined side-wall tubes with vertical headers, a division of the circulation into several distinct groups. (John Van Brunt, Vice-President, Combustion Engineering Corporation, New York, N. Y.)

Operating H.R.T. Boilers Above 150 Per Cent of Rating

F-8. Is the general impression among manufacturers and users of horizontal return tubular boilers that if maximum ratings exceeding 150 per cent are carried, bags and blisters may be expected, and consequently possibilities of explosions, well founded?

The statement has been made that it is possible to exceed this rating without serious consequences. One engineer has said that he has knowledge of a horizontal return tubular boiler which operated for six months at 300 per cent of rating on powdered-coal firing, and knows of another case of eight such hand-fired boilers which operated at over 200 per cent of rating for many years. It is quite possible that a large number of h.r.t. boilers have been operated at ratings higher than 150 per cent with good results. Brief statements from the operators of such boilers of special conditions, if any, which make this possible, should prove valuable. It would also be interesting to have specific evidence to support any attitude of limiting ratings to 150 per cent.—Editor.

Materials Handling

Dust Collectors[1]

MH-3 Centrifugal separators are being considered for installation in a dust-collecting system. Possible arrangements involve the use of one oversize separator or two small ones placed in tandem. Which arrangement is considered the better, and why?

The writer recently spent several months testing and developing a centrifugal type of collector, conducting tests on all types of dust materials ranging from coarse particles to fine dust, all of which passed through a 325-mesh screen. The choice of arrangement appears to depend largely upon the character of the dust to be collected, and also on the percentage of collection required. A single large collector is much more desirable unless the material is exceedingly light and fine and a high degree of separation must be achieved. (Arthur R. Wyman, H. K. Ferguson Co., Cleveland, Ohio.)

Power

Steam Temperatures[1]

P-1 What are the highest known temperatures for superheated steam, and for what purposes are they used?

Superheated steam has always held the intense interest of the writer since his first experience many years ago of an actual

[1] This subject has been discussed in a previous issue.

practical factory demonstration of its power when he saw crushed chrome ore allowed to flow into two opposing jets of this powerful gas with the result that the ore disintegrated and was reduced to a fineness of 260 mesh with only 6 per cent tailing at a cost of less than one-half that of any other method.

It seems strange that very little is known of the properties of superheated steam of temperatures higher than it is possible to use in a machine requiring lubrication—temperatures sufficiently high to burn the lubricant. Manufacturers of superheaters have said that it is impossible to superheat steam higher than 1000 deg. and control it with any degree of safety.

The writer has had over thirty years' experience in superheating steam to some 1300 deg. fahr., and has never yet heard of an explosion or any form of accident due to this temperature, excepting the failure of the bottoms of brass valves. Manufacturers are now producing special alloy valves which apparently withstand these temperatures. With a small demonstrating plant the writer has attained steam temperatures up to approximately 1550 deg. fahr. with no bad results.

The advantages of these high temperatures are unlimited. In addition to the apparently little-known possibilities of this method of pulverization, are the separation of the dross from the values of the various metallic ores by utilizing their varying specific gravities when brought down to a finely ground state, and also the very thorough drying of clays and other similar material which take up moisture from the atmosphere. There are many advantages in still another direction. Before entering this part of the discussion, the attention of the reader is called to certain facts as recognized in chemistry, as follows:

Steam is evaporated water, which is composed of two well-known elements, hydrogen and oxygen. Hydrogen gas ignites at 550 deg. fahr. and at 650 deg. fahr. the two gases, comprising steam, separate, and when brought into contact with sufficient oxygen to support combustion, will ignite. If combustion is supported, it will develop some 63,000 B.t.u. per lb., as compared with 14,500 B.t.u. per lb. of a first-class, high-grade bituminous coal. So much for theory. But, as to practice, the writer has actually attained a much higher evaporation rate than 15 lb. per lb. of coal, with the use of a fine-quality bituminous coal, in an h.r.t. boiler, when used in connection with superheated steam.

In various forms, this combination of heat and force would be most productive of results in chemical research. (Alfred B. Willoughby, Consulting Engineer, Philadelphia, Pa.

Railroad

Poppet Valves in Locomotive Cylinders

R-2. What advantages are claimed for poppet valves when used in locomotive cylinders?

Double-seated poppet valves have been applied on locomotives in Europe since 1900 (by Lentz), and have been adopted lately in the form of single-seated poppet valves on the Büchl, 420-lb. pressure locomotive of the Winterthur Locomotive Works. Both types require no lubrication, seat tightly, are simple, rugged, and light, allow the greatest reduction in cylinder clearance, and a complete independence in the succession of steam events. They stand very high steam pressures and superheat, and if well designed and made of low-carbon chrome-nickel steel, properly heat treated, will not warp.

A double-seated valve can be well balanced and requires with the usual locomotive boiler pressures (200 to 250 lb.) very little power to operate. Valves of 8-in. and 10-in. diameters have been used for exhausting steam from 30-in. cylinders, without any appreciable drop in pressure. If designed so as to open against the steam flow, the pressure ahead of the valve aids in keeping the valve tight when closed. The valve operates at its best with the stem in a vertical position, and if it is designed to open downward it falls open as soon as the throttle is closed and affords a natural, ample bypass when the engine is coasting.

Poppet valves can be built as self-contained units with their cages, permitting lifting and removal with little effort and waste of time. The mechanical problem of poppet-valve operation on locomotives has been solved successfully; the best solution being at present the Caprotti self-contained valve gear with rotational cam drive.[2]

It is probable that due to the above-mentioned advantages the poppet-valve gear will supersede in the near future the conventional piston-valve gear. (Tommaso Jervis, Milan, Italy.)

Questions to Which Answers Are Solicited

Uses for Waste Gypsum

M-6 For what purposes is the waste gypsum collected from the tables in plate-glass manufacturing plants used?

Stresses in Oil-Well Casings

PT-1 What methods are recommended for determining the types of stresses causing failure of oil-well casings at depths of 2000 to 3000 ft.?

Four Truck Axles in Engines With Three Driving Axles

R-3 How can we justify four truck axles when used in the same engine with three driving axles?

Developments in Long-Draft Spinning of Cotton Yarn

T-2 What are the latest developments in long-draft spinning of cotton yarn? Has any system of long-draft spinning been generally adopted in this country?

Correspondence

CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

Wages of Engineers

To the Editor:

In the April issue of Mechanical Engineering, on page 319, Thomas A. Normile takes exception to statements made by Crosby Field in the December issue and asks several pertinent questions relative to the status of the engineering profession as compared with that of the medical and legal professions.

While the state of affairs as related to engineering is deplorable, nevertheless the simile which Mr. Normile brings out in his communication and the tables he publishes showing the large percentage of medical and legal men practicing for themselves as compared with engineers, are based on an absolutely wrong premise.

In the practice of medicine and law every human being is a potential client. Furthermore, medical and legal work is not

[2] Mechanical Engineering, vol. 50, no. 8, August, 1928, p. 638; also, *Baldwin Locomotives*, vol. 6, No. 3, Jan., 1928, pp. 67–68.

concentrated and carried on on a large scale as is the engineering profession in industry. With the exception of interns practicing in hospitals and law graduates practicing temporarily in established law firms or in the legal departments of corporations, these men must necessarily carry on a private practice, otherwise they have no means of sustenance.

Furthermore, because of the very severe restrictions which safeguard the medical and legal professions from ordinarily irresponsible individuals practicing medicine or at the bar, these professions are held in high regard in the public mind, irrespective of individual ability.

On the other hand, many of our best engineers today are men who have grown up in the ranks and have learned the fundamentals of their profession in the school of experience rather than the college or university. The public, however, places no halo over the brows of such talent.

The engineer not gifted with business ability, personality, or engineering experience and knowledge obtains a position in one of the thousands of manufacturing and engineering organizations in our very complete industrial system.

If each individual in seeking medical assistance would use the same discrimination that financial industrialists or investors do in seeking the services of an engineer, the percentage of medical men and legal men as well in private practice would shrink to one comparable with that of the engineer.

In undertaking a new engineering development the amount to be expended becomes the paramount question, and extreme caution is exercised in appointing the proper engineering council or assistance so that all possible loss in such an undertaking will be avoided; on the other hand, however, the average person is less mindful and less cautious in trusting his personal health and welfare to the average practitioner.

When an engineer makes a mistake it is one that others can see and can talk about, and very often it results in the loss of lives and property. This is seldom the case in the medical and legal profession. One doctor will seldom criticise the work of a fellow-practitioner, although gross negligence or ignorance may be apparent. This is a fact which makes it possible for many medical men to practice their professions with impunity.

The legal profession comprises not only the practice of law but many other side issues such as insurance, real estate, building and loan, society work, and many other branches which are foreign or only slightly related to law. If all attorneys practicing today were restricted solely to the practice of law in courts or to the drawing up of agreements, their numbers would shrink very rapidly.

There are many things that the engineering societies can do for their individual members and the profession in general. But nothing that they can do will perceptibly increase the percentage of men practicing for themselves, particularly in the face of the increasing mergers of large corporations and the consequent absorption of capable engineering talent in such organizations.

To the writer's way of thinking, the problem of the wage scale and remuneration to the engineer will solve itself in due time. When drafting and designing prove to be unprofitable, young men will no longer be attracted to these classes of work. A shortage of designers will then be brought about—and is apparent even at the present time—and as our industries and the machine age are developing more rapidly than are good designers and engineers, a man of ability will find his place very quickly.

Men of real ability have very little difficulty in getting their full remuneration even at present. Inquire of any high executive in any engineering or industrial plant today, and he will tell you that right in his organization he has one or more positions open for really capable men, whose salaries will not be restricted but will depend solely on their own personal ability.

The profession as a whole may be raised in the esteem of the public by restricting indiscriminate education and by confining the practice of engineering to those who shall have passed certain examinations similar to those required in the legal and medical professions.

Personally, the writer does not think that the requirements for an engineer to successfully establish himself in private practice can be attributed to his capabilities, personality, or experience. There are quite a number of other factors such as business ability, perseverance, the capacity for hard work, and the innumerable characteristics which go to make up an all-around executive.

The writer has personally known many men whose ability was beyond question but who could not develop a practice, who had sufficient capital to carry them over all obstacles and whose personality was as charming as any one could wish. Their lack of success could be attributed, however, to shortcomings other than ability, personality, and experience.

J. S. PECKER.[1]

Philadelphia, Pa.

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretations of the Committee in Cases Nos. 621 and 622 as formulated at the meeting on March 22, 1929, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE No. 621

(In the hands of the Committee)

CASE No. 622

Inquiry: Is it permissible, under the requirements of the Code, to form the fire-door openings of vertical tubular boilers by inserting a ring of steel plate, through openings in the fire-box sheet and the shell of the boiler, and welding it at the edges to these plates?

Reply: It is the opinion of the Committee that the construction as proposed is not prohibited under the requirements of the Code. It is, however, the opinion of the Committee that the proposed fire-door construction should not be used on a boiler with a water leg of inside width in excess of $2^1/_2$ in., nor where the space between the ring and the edges of the openings in the plates exceeds at any place $^1/_8$ in.

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[1] Chief Engineer and Proprietor, Machine & Tool Designing Co. Assoc-Mem. A.S.M.E.

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers, and Proceedings of

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Chemistry and Engineering

A VISIT to the Twelfth Exposition of the Chemical Industries serves to emphasize again the close relation between chemistry and engineering. A first survey of the exhibits leaves an engineer with the impression that there is more engineering than chemistry to be seen, and gives weight to the statement often made that a chemist in industry needs an engineering training. The corollary to this statement, that the engineer is ill equipped for present practice unless he has had a thoroughgoing training in chemistry, will be admitted by most mechanical engineers. Engineers will also acknowledge a rapidly mounting debt to chemistry which has enlarged the scope of their practice, provided them with new materials, and given them control methods of enormous practical value in routine operations.

As soon as chemistry gets into industry its engineering aspects become more and more important. The ingenious contraptions of glass and rubber tubing contrived by the research chemist give way eventually to tanks, pumps, filter presses, driers, mechanical packaging and handling equipment, and a system of production control, all of which come within the province of the engineer. This mutual dependence of chemists and engineers on each other in industrial enterprises indicates that reciprocal benefits would result from well-organized professional contacts.

Encourage Publication!

IN AN ADDRESS on the encouragement of research workers which was delivered at a meeting of Section M (Engineering) of the A.A.A.S. last December and published elsewhere in this issue, Dr. W. R. Whitney, Director of Research, General Electric Company, drew attention to three means of supplying such encouragement: namely, increased financial remuneration, an opportunity to publish researches, and a chance to do more and better work.

The first and last of these are determined by economic forces, but the second may easily be ignored or treated unsympathetically by executives whose points of view are widely different from those whose creative energies have made contributions to human knowledge.

Scientists, like artists or poets, justly deserve whatever benefits may come from the distinction which publication of their work adds to their names. In university circles this is thoroughly recognized. To fill the most important academic post in a certain branch of science a man was recently chosen largely on account of the numerous excellent papers of which he was author. Had publication been denied him, his influence might have continued to be largely local.

In industrial circles publication is viewed differently. Sometimes publication must be delayed to preserve secrecy. Sometimes it is denied on what appear to be the most arbitrary grounds of a fixed negative policy.

The engineering societies, through their meetings and publications, afford an excellent medium for encouraging research workers and engineers in general whose discoveries and experiences put them in a position not only to benefit through the attention which is directed to them and their work but also to add their bit to scientific knowledge. A liberal policy on the part of industry, encouraging participation in such meetings and the publication of researches and contributions to engineering knowledge, will result in reciprocal benefits.

Training Geniuses

ANNOUNCEMENT that provision is being made at the Johns Hopkins University for the training of geniuses in medicine has called forth considerable comment in the daily press. Among engineers, too, there are geniuses, and the matter of their education is of interest and concern to the profession.

If by genius we mean the exceptional student, the interest broadens to include every engineering school. In every class an instructor will recognize the man who sticks out above his fellows, and will wonder if this individual is receiving the kind of instruction he ought to have. Some schools have excused men of this type from attendance at class and have regulated their study by conference with an instructor. Others have attempted segregation where numbers are large enough to admit of it, with the more brilliant students in one group and the mediocre and dullards in another. Such plans have their advantages and their disadvantages. A story is told in connection with one case of segregation which brought out entirely unexpected results. There seemed to be no desire on the part of the better students in the lower group to advance to the upper. Inquiry brought out the fact that the instructor of the lower group was expending such herculean efforts to advance his men that he was giving superior and highly appreciated instruction. With a less conscientious instructor this segregation method places a handicap on the dull but earnest student by removing the stimulus of more active minds.

Another story in connection with segregation is worth repeating. In a primary school where a group of brighter pupils forms the "rapid advance class," the epithet "rabbit advance class" has been applied by the pupils because they jump around so!

Training geniuses is a large order. Fortunately there are certain persistent qualities in geniuses which make it hard to spoil them completely by an improper method of education. One feels that perhaps the barn in the backyard of the house where Steinmetz lived and where Whitney and his associates started the re-

search department of the General Electric Company was the beginning of one of industry's schools for geniuses. Others are to be found in similar laboratories of other corporations, and in the engineering departments where laboratory researches are developed into definite and practical form.

Shifts in Industry

PRESS notices of the report of the committee on Recent Economic Changes of the National Bureau of Economic Research point out three phases of a study of industrial migration which show interesting tendencies. During the period covered by the report, i.e., since the end of the war, there has been found, first, a general shifting of industry from one section of the country to another, as is seen, for instance, in the textile industry, which has developed rapidly in the South at the expense of New England; second, a tendency toward the movement of industries into more rural communities; and third, indicated a decreasing concentration of certain industries in traditional centers.

Engineering has done much to concentrate populations and specific industries in certain sections of the country. A power site formed the nucleus of many a textile village in New England, and the particular skill which labor groups developed naturally led to concentration of an industry in a given locality.

Engineering is now supplying the means of developing the less congested areas outside of cities. The transmission of electrical energy emancipates the manufacturer from dependence on a water-power location or on one in which power may be favorably generated, while more rapid means of transportation and communication make distance less of a handicap both to industrial and to social life.

The contributions of engineering formed the basis of our industrial era and brought with them serious economic problems and social abuses. As these problems and abuses are studied and corrected, further contributions of engineering are likely to give rise to much more rapidly changing conditions than have yet been experienced. It is to the credit of engineering that its own progress is supplying the solution to many of the problems it begets.

Aircraft Terminals

MUCH has been written on this subject and a considerable body of engineering information has been developed. The economics—and possibly politics—of aircraft terminals, however, is still in a most inchoate stage. The first question is where should terminals be located. The principal claim for the superiority of aircraft to other means of transportation is (the present discussion is limited to densely populated sections of the country, in particular the Middle West and the Atlantic seaboard of the United States) its speed. Now, when we are talking about the speed of aircraft transportation, we do not mean merely the time it takes to travel from one field to another, but the time of the trip from start to finish. If a man can go from his office in Wall Street, New York, to the office of a man he wishes to see in Philadelphia, located, say, in Market Street, in two hours and twenty minutes, it does not help him any to travel from Roosevelt Field to the landing field in Philadelphia in fifty minutes, if he has to spend another hour and a half getting to Long Island from Wall Street and to Market Street from the landing field in Philadelphia.

From this point of view, fields ought to be located in the most immediate proximity to the business centers of their respective communities, substantially the same as railroad terminals are now located. However, the question of costs looms up in a terrifying manner. The experience of the Union Terminal Station in Cleveland shows what a tremendous investment in capital is required to locate a large terminal in the heart of an industrial city. In railroad operation such a terminal is intended, however, to handle literally millions of people a year, and we are still very far from handling similar numbers by air. To locate an aircraft terminal in the heart of an industrial city of modern metropolitan character, such as Cleveland, Pittsburgh, Philadelphia, or New York, would require an investment which can not be considered to be justified by the present magnitude of aerial traffic or by reasonable expectations of increase thereof in the near future. The result is that aircraft terminals are being located out of town, either in suburbs or near them. This obviously implies a loss of time in getting to one terminal and in reaching the point of destination from the other. A brief review of the situation now existing would indicate that this condition is aggravated in not a few instances by the fact that the roads leading to and from the aircraft terminals are unsatisfactory. In at least one case of a terminal located near one of the great centers of present aviation traffic, it has been stated that travel over the road to the terminal is far more dangerous and unpleasant than the flight itself. This condition can be remedied, of course, and should be at the earliest possible opportunity.

There is one further element which must be borne in mind when considering this matter of air terminals, and that is that the present terminal is based on an airplane that needs a very large field on which to operate. While the autogyro is still in the nature of an experiment, it has nevertheless shown that an airplane design is possible which will permit landing on a very restricted area, as well as taking off therefrom. Who knows but what after investing millions of dollars in huge fields of the present type, we shall begin to use planes that can land within an area no larger than a city block? It is clear, however, that aircraft will not accomplish all that they are capable of as regards providing a new and valuable means of transportation until a satisfactory ground equipment in the way of regular and emergency fields has been developed, just as the automobile in the United States would not have reached its present amazing proportions had it not been for the billions of dollars invested in the last twenty-five years in good roads. Putting it bluntly, if not perhaps elegantly, aircraft will continue to stay up in the air until they get their feet on the ground.

There is another rather significant feature of the aircraft-terminal situation which must be taken into consideration. The airplane in its initial stage enjoyed to an unusual extent the public favor. Every one realized the importance of the development of the flying art and the risks taken by its pioneers, both technical and commercial. Nothing, therefore, was too good for the fliers, and this spirit still prevails in many parts of the country, particularly in the Middle West. But today aviation has reached the stage of the $100,000,000 companies; it is a big business, and the old spirit of adoration is beginning to evaporate gradually. This was significantly shown in the treatment of the three companies which endeavored to obtain a seaplane landing place at West 79th Street, North River, New York. Not only was there developed a powerful opposition which led to prompt cancellation of the temporary permit, but the Mayor of New York, according to the New York *Times*, made the remark that there was no reason why aircraft companies should seek a landing place within twelve minutes' ride from Times Square. Accordingly the *Times* in an editorial suggested as an ideal place for seaplane operation the Tappan Zee, forty-five minutes' ride by train from the Grand Central Terminal. The Tappan Zee is a baylike expansion of the Hudson River near Tarrytown, New York, and about three miles wide. As aviation develops more and more into the class of big business, the tendency to help it along by outside grants, such as landing fields, etc., will probably disappear, just as grants of land are no longer made to encourage railroad construction.

Herbert Hoover[1]

Engineer, Scholar, Organizer of Relief to War-Stricken Peoples, Public Servant

HERBERT HOOVER, President of the United States of America, received the twenty-fifth John Fritz Medal April 25, 1929. The tentative award was made in October, 1927, and confirmed a year later.

Ancestors from Holland and France settled in America in colonial days. They were members of the Society of Friends (Quakers) and Huguenots. A later generation migrated to Iowa and with other Quakers founded the town of West Branch. Here Herbert was born August 10, 1874, son of Jesse Clark and Hulda Randall (Minthorn) Hoover. Jesse Hoover was a farmer, blacksmith, and dealer in farm implements; he died in 1880. After Herbert's mother died in 1884, he lived with relatives, in Iowa, in Indian Territory (among the Osage Indians) and in Oregon. When thirteen years old, he began to earn a living by working in truck gardens around Portland, became an office boy in Salem and later a clerk in Portland. In night school and the Pacific Academy at Newberg he prepared for college and was one of the first entrants in 1891 of the newly established Leland Stanford Junior University, at Palo Alto, California. Summer vacations were spent in geological surveys. He earned his way. He was graduated with the class of 1895 from the department of geology and mining.

Soon after college Hoover sought and found a job, in the office of Louis Janin, well-known mining engineer of San Francisco, as a clerk. In a short time he was made an assistant in the examination and operation of mines in several western states. In 1897 he went to West Australia by engagement with an English firm of mining engineers, and spent two years in examination and development of a number of important mines. In 1899 he was appointed Chief Engineer to the Chinese Imperial Bureau of Mines. On the way to this post he stopped in California to marry Miss Lou Henry, of Monterey, a fellow-graduate of Stanford University. She accompanied him to China. They were in Tientsin through the Boxer uprising. He was a leader during the distressing weeks of siege and organized the distribution of the scanty food supply. Mrs. Hoover aided in nursing the wounded and the sick. Changes in government caused a collapse of official mining activities, and so after an examination for the foreign bondholders of the properties of a large coal-mining, railway, and shipping company, seized by various powers, he returned to California in 1900.

Active practice of mining engineering in ten or more countries followed. He introduced American methods and machinery extensively. In five years, 1902 to 1907, he made five trips around the world. He maintained his residence, however, at Monterey, California, until 1906, and in that year built a new home on the campus of Stanford University. In 1902 he became junior partner in a firm of engineers having offices in England, America, and Australia. Another partner, without knowledge of his associates, lost heavily in speculations that involved the firm. Hoover, in the absence of the remaining partners, announced that although the firm was not legally responsible, the losses would be made good—and they were, within five years. This partnership was ended in 1907. Thereafter Hoover practiced independently, from offices in New York, San Francisco, London, Russia, and other places, as consultant in the administration and reorganization of large mining, metallurgical, and transportation enterprises. Employees of the companies for which he was executive engineer totaled 175,000 in 1913. Operations under his administration were never interrupted by strikers. Because of his thorough technical knowledge, his wide experience, his keen observation, his resourcefulness, his ability to organize, his sound judgment, his good sense, and his business capacity, his professional services were in great demand.

To promote foreign participation in the Panama-Pacific Exposition of 1915, Hoover went to Europe in the spring of 1914. He was in London when declarations of war initiated the great conflict. Repatriation of two hundred thousand Americans from the embroiled countries was an instant problem. Transportation was out of gear and ready money scarce. American Ambassador Walter Hines Page asked Hoover to organize relief. He had already privately been aiding acquaintances effectively. Soon the tangle was straightened out under his leadership and five thousand Americans a day were being shipped homeward. In the late summer, Mrs. Hoover, who had been helping the Women's Committee, sailed with their two sons, Herbert Clark and Allan Henry. Hoover planned to follow in late September, after disposing of affairs in hand.

In Belgium and northern France ten million people already were threatened with starvation as a consequence of the German invasion. Millard K. Shaler, an American mining engineer long resident in Belgium, knowing of Hoover's abilities but not personally acquainted, approached Hoover through Edgar Rickard, another American mining engineer then closely associated with Hoover in London. Hoover told Shaler how to buy and load supplies, but the Allied blockade of Germany prevented getting them into Belgium. Hoover took Shaler to Ambassador Page. Hugh Gibson, then First Secretary to the United States ministry at Brussels, and three eminent Belgians also had sought through the Ambassador the succor of the greatest neutral nation. They agreed upon Hoover as the one man competent to undertake the

[1] From program of ceremonies on the occasion of the presentation of the John Fritz Gold Medal to Herbert Hoover by the John Fritz Medal Board of Award, April 25, 1929, at the Executive Mansion, Washington, D. C.

apparently impossible task. Putting aside personal affairs at great sacrifice, he undertook to create the Commission for Relief in Belgium. Giving up a lucrative engineering and business career, he became the great organizer of relief to war-stricken peoples.

Rich and poor alike in the enemy-occupied areas must be supplied immediately with food and other necessaries, but the provisions must not be used by the enemy. Hoover, the diplomats of the United States, and his other associates gained the consent of the blockading Allies and of the Germanic powers over great obstacles. Hoover's interview with Lloyd George, who opposed for military reasons, ended abruptly with: "I am convinced; you have my permission." Arrangements for purchasing, transporting, and distributing supplies on an unprecedented scale were developed with amazing celerity. Financing by solicited contributions and governmental appropriations was secured. The Dutch and Spanish ministers cooperated. Operations were put upon as business-like a basis as practicable. Persons who could pay for provisions were expected to do so. Transactions reached a volume represented by the use of $25,000,000 a month and a total in four years of $1,400,000,000. The Commission took on some of the attributes of a government. It operated its own fleet of two hundred ships under its own flag, with immunity from submarine attack and blockade. It had its own canal boats, railways, warehouses, mills, bakeries, factories, and distributing stations. Surplus from sales was devoted to support of schools, local governments, and employment activities. Ultimate closing of the business showed a balance of $25,000,000. Portions of this money were given to the Belgian universities crippled by the war, and the remainder was used to establish permanent foundations for the aid of Belgian education. When the United States declared war, Hoover and his American staff were directed to leave Belgium, but he continued to be the head of the Commission for Relief in Belgium.

Hoover returned to the United States in May, 1917. President Wilson appointed him Food Administrator. On Hoover's recommendation Congress passed a food-control bill. He so organized the nation on lines of voluntary service for increase of production and decrease of consumption that the deficiencies of the Allies were met so far as it was feasible to make deliveries. Profiteering was controlled and the cost of subsistence prevented from soaring. He created the United States Grain Corporation with $500,000,000 capital and the Sugar Equalization Board, capitalized at $5,000,000 both wholly owned by the Government. Prices for farm products were determined by independent commissions representing the producers. Foodstuffs to a total exceeding $9,000,000,000 were bought and sold by the Food Administration. When its work was done, its capital was returned without diminution to the Treasury.

During the participation of the United States in the war, Hoover and the secretaries of State, Commerce, and Agriculture were a commission for regulating exports and imports through the War Trade Board. He was chairman of the Inter-Allied Food Council and a member of the President's War Council.

Although stupendous and vital were the services performed by Hoover in those dark years of world conflict 1914–1918, future generations may appraise as of even greater value to humanity his achievements after the Armistice. As Director-General of the American Relief Administration and chief executive of the Supreme Economic Council, he organized and directed assistance to numerous war-damaged peoples of Europe and the Near East—food, medical supplies, sanitation, care of children, funds for education, and reorganization of national finance, of industry, and of employment. At the request of governments of central and eastern Europe he controlled shipping, railways, mines. In twenty-three countries food administrations were established. Ports were opened. Commerce between countries recently enemies was resumed. Anarchy was averted. Appalling typhus epidemics in Roumania and Poland were checked. Through the European Children's Fund, a charitable organization set up by Hoover, six million ill-fed, outcast children were sheltered, fed, and clothed. Late in 1919 he returned to his California home.

In the winter of 1920–1921, in central Europe, three and a half million destitute children were aided by means of $33,000,000 raised through American charitable agencies in campaigns initiated by Hoover. Large numbers of the intelligentsia were also given assistance. In the summer of 1921 Russia's great famine and epidemics resulting from war and revolution requisitioned Hoover's ability to marshal men and resources to save millions of lives. Again tremendous results were accomplished with amazing celerity.

In 1923 the American Relief Administration was disbanded. Since 1914 Hoover and his close associates had been engaged in the business of mercy on a scale never before attempted. Putting aside personal business and profession, they accepted no payment for services, no reimbursement for travel expense, and even gave generously to the funds of the charitable enterprises which they directed. In all these vast activities Hoover was a true leader, attracting the loyalty and the devoted services of thousands of persons of all nationalities and social ranks. The effecting of these colossal humanitarian services in the direst calamity which has befallen the modern world was a "notable industrial achievement" in the highest signification of that phrase. Multitudes of industries of all kinds were coordinated and combined for supreme service to the peoples of the earth. Their efficiency was improved. Their energies, their products, and the wealth created by industry were directed now here, now there, to meet unprecedented emergencies, over unparalleled hindrances.

President Harding chose Hoover to be Secretary of Commerce in March, 1921, and President Coolidge continued him in that office. He resigned July 7, 1928, on account of his nomination for the presidency of the United States. In the interval, with the voluntary aid of thousands of engineers, business men, and industrialists, he developed the Department of Commerce into a powerful factor in industry and business through collection and convenient dissemination of information, through simplification, waste reduction, and research—all carried on cooperatively.

Besides the numerous activities already mentioned, Hoover rendered other important services. He was in 1919–1920 vice-chairman of the second industrial conference, which led to better internal relations in many industries. In the 1921 business depression he brought about the President's Unemployment Conference. He was a member of the advisory committee of the Washington Limitation of Armaments Conference. In 1922 he was chairman of the Colorado River Commission, to determine the equitable allocation among seven states of the utilization of its water. He also inspired the organization of the American Child Health Association that same year, becoming its president. In 1927 he was chairman of the Special Mississippi Flood Relief Commission. Since 1912 he has been a trustee of Stanford University.

Hoover's scholarly attainments are attested by his contributions to the literature of his profession. He is also a broad and retentive reader. In 1905 he was one of a group of authors who produced the book, "Economics of Mining." In 1909 he condensed into "Principles of Mining," a well-known textbook, lectures given in courses at Stanford and Columbia universities. In 1912 there resulted from five years of studious diversion, with the collaboration of Mrs. Hoover, a critically correct trans-

lation into English of Agricola's medieval Latin "De Re Metallica," originally published in 1556 and perhaps the first printed treatise on mining and metallurgy. It was a great work, and so is the translation, with its copious notes by the translators. "American Individualism" also came from his pen, 1922. Many of his addresses and technical papers have been published.

Hoover is a past-president of the American Institute of Mining and Metallurgical Engineers, of the Mining and Metallurgical Society of America, and of the American Engineering Council. He is an honorary member of the American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, and American Society of Mechanical Engineers.

Honorary degrees have been conferred by Brown University, University of Pennsylvania, Harvard, Yale, Columbia, Princeton, Johns Hopkins, George Washington, Dartmouth, Boston, Rutgers, University of Alabama, Oberlin, Liége, Brussels, Warsaw, Cracow, Oxford, Rensselaer, Tufts, Swarthmore, Williams, Manchester, University of California, Virginia, Prague, Ghent, Lemberg, Lwow, and Cornell.

He has been awarded medals or prizes by the Civic Forum, National Institute of Social Sciences, National Academy of Sciences, American Institute of Mining and Metallurgical Engineers, Western Society of Engineers, City of Lille, City of Warsaw, Audiffret prize, French Academy, John Fritz Medal Board of Award.

His honors from governments include: Honorary citizen, Belgium; freeman, Belgian, Polish, and Esthonian cities.

On the testimony of his record, Hoover's engineer colleagues have awarded him their highest honor, the John Fritz Gold Medal for notable scientific and industrial achievement, as engineer, scholar, organizer of relief to war-stricken peoples, public servant.

The John Fritz Medal

The John Fritz Medal is the honor given jointly by four national engineering societies having sixty thousand members: namely, The American Society of Civil Engineers, The American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, and The American Institute of Electrical Engineers. It was established in 1902 in honor of John Fritz, of Bethlehem, Pennsylvania. The medal is of gold and is awarded, not oftener than once a year, for notable scientific or industrial achievement, without restriction on account of nationality or sex. It is accompanied with an engraved certificate. This certificate states the origin of the medal, the specific achievement for which the award is made, and bears the names of the members of the Board by which the medal was awarded and the signatures of the President and Secretary of the Board.

The Board of Award is formed of sixteen men, four representatives from each of the four National Societies. The members of the Board for 1928 which awarded the medal to Herbert Hoover were:

American Society of Civil Engineers

C. E. Grunsky — George S. Davison
Robert Ridgway — John F. Stevens

American Institute of Mining and Metallurgical Engineers

William Kelly — Samuel A. Taylor
J. V. W. Reynders — E. L. De Golyer

American Society of Mechanical Engineers

Fred R. Low — Dexter S. Kimball
D. S. Jacobus — Charles M. Schwab

American Institute of Electrical Engineers

Farley Osgood — Cummings C. Chesney
M. I. Pupin — Bancroft Gherardi

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Engineering Aerodynamics

Engineering Aerodynamics. By Walter S. Diehl. The Ronald Press, New York, 1928. Cloth, 6 × 9 in., 288 pages, diagrams and tables, $7.

Reviewed by Richard M. Mock[1]

THE writing of Diehl's "Engineering Aerodynamics" is the answer to a long-felt demand for a publication giving complete aerodynamical information in a form convenient for ready reference. The author has endeavored to meet a need for more practical information on aerodynamics as well as to add a very considerable amount of original data to what is already available. Much of the information given has never been published heretofore.

[1] Aeronautical Engineer, Bellanca Aircraft Corp., New Castle, Del. Jun. A.S.M.E.

The book makes no claim to being elementary, but rather assumes that the reader has a fair foundation in aerodynamics. Advanced mathematics is omitted as are descriptions of tests, test data, and test methods, the results being given in a digested and easily understandable manner. It is evident that an effort has been made to present the subject in as simple and concise a form as possible, and to include many references for those requiring more complete information. Many curves and charts are presented to facilitate the use of the mass of data available.

The first chapters are devoted to airfoil data and theory, taking into account the many variables such as cut-outs, ailerons, etc., as well as those factors affecting efficiency. Many curves are included, showing the effects of these variables.

A succeeding chapter is devoted to the study of model testing and parasite resistance, and considerable space is devoted to the latter. This important subject is discussed in its various

phases, taking into account all sorts of shapes and analyzing them. Curves and data give the resistance of the various parts of the airplane. In addition to the usual details discussed, attention is given to floats and float design.

The one subject which is receiving so much attention today, namely, control-surface design, is covered quite completely, the author presents many results and much basic theory in a digested form. The effects of various shapes, aspect ratios, and sections are presented and discussed.

Engine and propeller considerations are included, followed by a series of chapters on performance calculations, factors affecting performance, and flight testing. The various details of performance calculations are gone over briefly, and then the variation of rate of climb with altitude is discussed in detail in a separate chapter. Following this parasite drag is again discussed, an entire chapter being devoted to the effect of aspect ratio.

The chapters on flight testing start with one on the reduction of observed performance to standard conditions. This takes into account all the phases of airplane performance. Under notes on flight testing is given information on the calibration of instruments and on the effects of airspeed on climb and its variations with temperature and pressure.

Airplane range and endurance from the theoretical viewpoint are covered in detail, followed by a series of special flight problems such as gliding without power, circular flight, spiral flight, effect of a diving start on speed calculations, limiting speed in a dive, take-off and landing runs, etc. A few paragraphs on flat spins and the descent of a parachute conclude the chapter.

It has often been necessary to estimate the effect in performance of an airplane due to various slight changes in design. In these cases it is not desirable to make a complete performance calculation. The author has devoted some space to this subject, discussing the various phases of airplane performance and how they are changed by certain variables.

The last chapter is on a subject that in most texts has, until recently, been neglected, that is, seaplane floats. The aerodynamics and hydrodynamics of float design are covered in detail.

The book includes an appendix giving standard atmosphere data, various conversion factors, and useful formulas.

The New Way to Net Profits

THE NEW WAY TO NET PROFITS. By Fred W. Shibley. Harper & Bros., New York, 1928. Cloth, 6 × 9 in., 213 pp. $3.

REVIEWED BY HUGO DIEMER[2]

MR. SHIBLEY'S book is good testimony to the effect that among bankers there are to be found men who have subjected themselves to the discipline of a thorough study of management science and philosophy. That Mr. Shibley has done this is apparent throughout his book. There have been previous authors who, in a general way, have advocated the correlation of sales, finance, and production, but it has remained for Mr. Shibley in his book to point out clearly how this coordination can be practically brought about. He points the way to plan definitely in advance the number of sales dollars to be earned, and shows how these sales dollars can be apportioned in each field of activity in such a manner as to provide for a net profit.

An interesting foreword of ten pages has been written by Donaldson Brown, vice-president of the General Motors Corporation, in which he emphasizes the fact that Mr. Shibley points the way to a system of control whereby production, purchase of materials, and the employment of capital are coordinated with sales requirements. The focal point of the system is the sales outlet. The flow at this point must be gaged, and every other activity must be coordinate with it. In order to bring about the coordination indicated we need an exact knowledge in advance of what the public wants and how much it wants, and a regulation of production in accordance with these ultimate consumer demands. Among the constructive efforts required to bring about the desired results are "long-term" and "short-term" factors. Among the long-term factors are programs of research to increase the appeal to the consumer. Short-term factors are those that may be quickly called into play to offset unfavorable developments. The reason for this new order has been the saturation of markets as a result of mass production. Consumer purchasing capacity exists to an inconceivably large extent, but it must be catered to to an exasperating degree before purchasing demand is set into operation. This requires market studies involving consumer psychology and appraisal of purchase trends by personal contact with consumers. Market research is doing for marketing what production research has done for production.

The science of merchandising involves a thorough examination of all facts which can be ascertained in relation to such matters as quality, design, style, color, preparation, and service, so that consumer acceptance can be anticipated with reasonable confidence. Distribution studies may involve the demonstration by the manufacturer of entirely new methods, and proving their success before the retailer will accept them. Salesmanship is the most important link in the chain of distribution. Scientific training of salesmen is as important as the scientific planning of production or inventory control. The sales forecast evolves naturally from the study of markets and from the scientific methods of merchandising and distribution.

After having covered the foregoing subjects clearly, the author shows their direct connection with production planning and budgetary control. He concludes with chapters on management, research, and analysis. In his chapter on management he emphasizes the importance of directors chosen because of special ability as wise advisers rather than because they represent large holdings. He deplores the prevalence of what he calls "Bourbon" management, which sits aloft and looks wise without really knowing anything, and holds subordinates in fear. The author contends that business workers and labor today have a shrewd and comprehensive opinion of what constitutes good management. In his chapter on research he points out that research is becoming exceedingly practical.

Analysis, the author says, is the most fascinating of all mental pursuits. There is no principle of scientific administration which in its application does not require analysis.

Engineers who have been advocating the foregoing ideas should find great encouragement in the fact that a bank official is pleading their cause with the strong endorsement of the vice-president of the world's most successful large corporation.

[2] Director of Personnel and of all Business Management Courses, LaSalle Extension University, Chicago, Ill. Mem. A.S.M.E.

Elements of Practical Mechanics

THE ELEMENTS OF PRACTICAL MECHANICS. By Chas. Ronald Macinnes. D. Van Nostrand Company, Inc., New York, 1929. Cloth, 6 × 9 in., 130 pp., 146 figs.

REVIEWED BY PROF. W. R. BRYANS[3]

A CONCISE, well-written textbook on the conventional topics ordinarily covered in an undergraduate course in applied mechanics. Its outstanding merits are freedom from "padding" and the inclusion of an ample number of well-selected drill problems. As in most texts on applied mechanics, the treatment of dynamics of rotation is not all that could be desired.

[3] Professor of Mechanics, New York University. Mem. A.S.M.E.

Books Received in the Library

Aircraft Float Design. By Holden C. Richardson. Ronald Press Co., New York, 1928. (Ronald Aeronautic Series.) Cloth, 6 × 9 in., 111 pp., illus., diagrams, tables, $5.

A discussion of the fundamentals of float shapes and arrangements, intended to assist the designer in selecting a satisfactory arrangement and correct proportions, and in determining performance. The book presents material that has not been available heretofore in connected form.

Carbonization Technology and Engineering. By John Armstrong. Charles Griffin & Co., London; J. B. Lippincott Co., Philadelphia, 1929. Cloth, 6 × 9 in., 471 pp., illus., plates, tables, $17.50.

This treatise gives a concise yet comprehensive view of carbonization practice, particularly by-product coking. The author has been engaged for forty years in designing and building industrial furnaces and investigating fuels. His book incorporates his conclusions, as well as the views of other authorities.

Les Coefficients Caractéristiques des Turbo-Machines et des Machines Volantes. By W. Margoulis. (Travaux du cercle d'études Aérotechniques, fasc. 1.) Le Centre de Documentation Aéronautique Internationale de l'Aéro-Club de France, Paris, 1928. Paper, 8 × 10 in., 16 pp., diagrams, tables.

This brochure, the first issued by the Cercle d'Études Aérotechniques of the Aero-Club de France, is a contribution to the standardization of the coefficients used in aerodynamics. The author, former director of the Eiffel Laboratory, presents a scheme for unifying the characteristic coefficients of screw propellers, turbines, turbo-blowers, and aircraft. The coefficients that he proposes for adoption are given and explained.

Practical Hydraulics: A Series of Rules and Tables. By Thomas Box. Seventeenth edition. E. & F. N. Spon, London, 1928. Cloth, 5 × 8 in., 112 pp., illus., tables, cloth. 6s.

This new edition has been revised and reset, and additional tables added. The rules cover the ordinary hydraulic problems met in practice, and the formulas are simple arithmetical ones.

Untersuchungen an der Dieselmaschine. By Kurt Neumann. Untersuchungen zur Dynamik des Zündvorganges. By Otto Klüsener. V.D.I. Verlag, Berlin, 1928. (Forschungsarbeiten, heft 309.) Paper, 8 × 12 in., 35 pp., illus., diagrams, tables, 6 r.m.

The first of these reports describes an investigation of the phenomena occurring in the preliminary combustion chamber and the cylinder of precombustion Diesel engines. It is based on elaborate tests made upon an 18-hp. Koerting engine under full load. The second is a study of explosions in cylindrical vessels, undertaken to determine the velocity of explosion and the influence of vortexes upon it.

Der Wärmeübergang beim Kondensieren von Heiss- und Sattdampf. By M. Jakob and S. Erk; also Die Verdampfungswärme des Wassers und das Spezifische Volumen von Sattdampf für Temperaturen bis 210° C. By M. Jakob. (Forschungsarbeiten, heft 310.) V.D.I. Verlag, Berlin, 1928. Paper, 9 × 12, 19 pp., diagrams, tables, 3.50 r.m.

Although steam is our most important technical conveyor of energy, but little is yet known about some of its properties, because of the difficulty of experimental investigation of them. This is true, for example, of the process of condensation, which is so incompletely understood that it has been uncertain whether superheated or saturated steam is most effective in this case as a heat carrier. The first report in this pamphlet describes a study of the comparative values of the two, the conclusion being that they are equally efficient, if the steam condenses.

The second report is on a study of the heat of vaporization of water, and gives the results obtained between 30 deg. and 210 deg. cent.

Wege und Ziele des Deutschen Museums. By W. Von Dyck. Heinrich Hertz. By J. Zenneck. (Deutsches Museum. Abhandlungen und Berichte, heft 1 & 2.) V.D.I. Verlag, Berlin, 1929, vol. 1, 30 pp.; vol. 2, 36 pp. Paper, 6 × 8 in., illus., portraits. 1 r.m. each.

These pamphlets are the first two numbers of a bi-monthly publication which will be issued under the auspices of the Deutsches Museum and the Society of German Engineers, and which will be devoted to brief popular accounts of important technical developments, biographies of scientists and engineers, museum collections, etc.

The first number contains an account of the beginnings of the Deutsches Museum, of its organization, developments, and purposes. The second is devoted to an account of the life and work of Heinrich Hertz, in which Dr. Zenneck gives an able brief review of his discoveries and their influence on electrical engineering.

Widerstandsmessungen an Umströmten Zylindern von Kreis- und Brückenpfeilerquerschnitt. By F. Eisner. Julius Springer, Berlin, 1929. (Mitteilungen der Preussischen Versuchsanstalt für Wasserbau und Schiffbau, Berlin. Heft 4.) Paper, 8 × 11 in., 98 pp., illus., diagrams, tables. 10 r.m.

This is an experimental contribution to the question of the resistance to motion of solids in liquids. It is the first portion of a comprehensive, systematic investigation of the resistance of structures resembling bridge piers in open channels, and of the effect of various shapes upon their resistance. The present report is in three parts. Part one shows the distribution of pressure and the amount of resistance in the case of cylindrical bodies. Part two is a review of the present teachings of hydrodynamics concerning resistance and the formulas proposed for computing it. Part three gives the results of experiments with bodies similar in cross-section to bridge piers.

These investigations were made at the Prussian Experimental Institute for Hydraulic Engineering and Naval Architecture, and have been in progress since 1913.

Zugfestigkeit und Härte bei Metallen. By Otto Schwarz. (Forschungsarbeiten, heft 313.) V.D.I. Verlag, Berlin, 1929. Paper, 8 × 11 in., 34 pp., diagrams, tables. 6 r.m.

With the growing use of non-ferrous metals and the very general use of the ball test upon semi-finished and finished products, a clear understanding of the theoretical and practical connections between tensile strength and hardness becomes very important. These relations are very carefully studied in this report. The author first investigates the question theoretically and derives laws showing the relationship. He then describes his laboratory investigations in detail, gives the experimental results obtained with brass, nickel, aluminum, duraluminum, and skleron, and supplies tables, based on these results, giving the factors for converting hardness into tensile strength. The relation of strength to hardness for copper and steel at higher temperatures and for cast metals is also shown.

Wave Mechanics; being one aspect of the New Quantum Theory. By H. T. Flint. Methuen & Co., London, 1929. Cloth, 5× 7 in., 117 pp., diagrams, 3/6.

This little book aims to present in a reasonably simple manner an account of wave theory of mechanics as developed by de Broglie and Schroedinger. It is intended for those not in close contact with recent work in physics who wish to become familiar with this new method and its relation to existing theory. References to more advanced works are included.

Synopses of A.S.M.E. Transactions Papers

THE papers abstracted on this and following pages appear in the current issues of Fuels and Steam Power, Hydraulics, and Materials Handling sections of A.S.M.E. Transactions. These sections have been sent to all who registered in the similarly named Divisions. Other sections are in the course of preparation and will be announced, when completed, in later issues of "Mechanical Engineering."

FUELS AND STEAM POWER PAPERS

Constitution and Classification of Coal. By A. C. Fieldner. [Paper No. FSP-50-51]

In an endeavor to picture compactly the status of our knowledge of coal constitution as it relates to classification on scientific principles, the author first discusses the nature of coal and its formation. He then takes up successively the questions of classification of coal by rank; the relation between classification by proximate analysis and ultimate analysis; Parr's system of classification; influence of composition of vegetable deposit; classification on macroscopic and microscopic appearance of coal; classification on the basis of types of chemical compounds in coal; and destructive distillation with reference to constitution of coal.

Burning Characteristics of Different Coals. By Henry Kreisinger and B. J. Cross. [Paper No. FSP-50-52]

This paper gives analyses of 20 typical American coals and also describes their general appearance and burning characteristics. Results of reactions in the fuel bed are then studied, and it is shown how the characteristics of the flame are affected by the composition of the gases rising from the fuel bed and the manner in which oxygen is supplied for their combustion. The paper then proceeds to deal with high rates of combustion caused by high relative velocity, compares the processes of combustion in fuel-bed and in powdered-coal furnaces; combustion of volatile matter in powdered coal; burning coking and free-burning coals in pulverized form; and, finally, with the fusibility of ash.

Washing and Preparation of Coal. By H. D. Smith. [Paper No. FSP-50-53]

In this paper the author briefly describes the various wet-washing and dry-cleaning processes in common use, and gives data which afford some idea of costs of cleaning and preparation from the coal-operator's standpoint. The difficulty of arriving at the increased value of the cleaned coal to the consumer is pointed out.

Progress Toward Direct Firing of Boilers With Producer Gas. By William B. Chapman. [Paper No. FSP-50-54]

The purpose of this paper is to awaken interest in the subject of heating boilers with producer gas. While there are no large installations in existence, nevertheless enough experimental work has been done on which to base grounds for further experimentation in the belief that there can be worked out a really commercial application of producer gas for boiler firing, obtaining all of the advantages of firing fuel in suspension and without the attendant disadvantages of ash in suspension. It can be done, the author believes, without any greater cost for the installation, without any greater amount of attendance, and with at least an equally good facility for adapting to changes in load. There are real possibilities, at least in all the medium-sized boilers, to justify the expectation that it will not be many years before boilers will be generally heated with producer gas, and more efficiently than they are now heated in the average-sized units.

Industrial-Furnace Efficiency, Economic Consideration. By James H. Herron. [Paper No. FSP-50-55]

The determination of accurate costs of furnace operation is an intricate problem. Some of these are intangible, and therefore difficult to determine. The different factors that are evident in furnace operation are brought out, so that possible furnace users may properly evaluate them and be able to apply them to their particular need and problem.

The Use of Fuels in Tunnel Kilns. By W. E. Rice. [Paper FSP-50-56]

In this paper the author deals with the use of fuels in continuous heating furnaces of the railroad-car tunnel type, which furnaces at present provide the most efficient means of heat-treating such materials as metallurgical products, steel sheets, carbon electrodes, brick, tile, pottery, etc. He first takes up the various fuels—gas, oil, and coal, following which he deals with the movements of the gases in the various zones of the kiln; and finally with the confinement of products of combustion in muffles when accurate control of atmosphere is required as in the case of many high-grade metallurgical and ceramic products.

Recent Developments and Improvements in the Baffling of Vertical Boilers. By A. C. Danks. [Paper No. FSP-50-57]

The author describes various arrangements of baffling and gives results of tests of the vertical boilers in which they were incorporated. From the figures presented he believes that the following conclusions can be drawn:

1 Increased rating is available when changing from vertical to cross-baffle, compared with either three-pass or four-pass of the vertical type.

2 Reduction in stack temperatures when the three-pass boiler is compared with the cross-baffle in addition to increased rating and uniform or slightly lower temperatures for equal ratings when the four-pass vertical boiler is compared with the cross-baffle, but with the increased ratings available with a corresponding increase in stack temperatures.

3 Lower draft drop through the boiler with cross-flow than with either the three-pass or the four-pass, the improvement being much greater in the latter case.

4 The elimination of dead gas pockets and of dust pockets in some particular arrangements of the vertical baffle.

5 The construction used renders the loss of part of the baffle impossible and insures a gas-tight baffle at all times.

6 A flexibility of design that admits of changes to suit the conditions under which the individual boiler is to be operated and that permits the removing of the serious restrictions often encountered in the earliest type of baffling.

To accomplish these improvements, several fundamental considerations have been found to be important, possibly the most important of which is to secure the maximum length of cross-travel over the tubes; secondly, to have this travel as at nearly right angles to the tubes as is possible; and lastly, to include as much of the total heating surface in the first two passes as possible.

Present Tendency of Boiler-Water Conditioning. By R. E. Hall. [Paper No. FSP-50-58]

The author first discusses the scope of boiler-water conditioning under the high pressures and ratings that characterize present-day plant operation. He then deals with the relations of the water to its various contacting surfaces and the matter of steam-liberating space. Maintenance of conditions, he concludes, constitutes the main theme of the systematic and exact water conditioning which is a necessity for modern generators. To make systematic water conditioning a reality, it has been necessary not to introduce new chemicals, not to specify equipment, but to define with exactness those relations for the contacting water which protect the surfaces from economizer or heater to turbine. Specific type of equipment for realizing the essential relations is secondary to their maintenance and is a matter of indifference from the standpoint of water conditioning so long as it is sufficiently flexible to permit simple and dependable maintenance.

Collecting the Dust From Chimney Gases of Powdered-Fuel Installations. By K. Toensfeldt. [Paper No. FSP-50-59]

In this paper the author, after sketching briefly the present status of the art, enumerates the factors that enter into the determinations of suitable apparatus for collecting pulverized-fuel flue dust. He then describes various types of collection, giving results of tests made on

them. He concludes that in general the problem of eliminating the flue dust from modern pulverized-coal installations requires the removal of that major proportion of dust which is so fine that it passes through a 300-mesh sieve, and that the size and type of apparatus required for the work depend upon the degree of dust removal it is desired to obtain.

FINENESS OF PULVERIZED FUEL AS AFFECTED BY MILL TYPES. By Lincoln T. Work. [Paper No. FSP-50-60]

Fineness of pulverized coal is increasingly important for small combustion space, as with Scotch marine, high-pressure, or small industrial boilers. The amounts of sieve size affect the completeness of combustion with correspondingly higher boiler efficiency and less smoke, while the amounts of superfine material affect the ease of combustion and the rate of radiation.

This investigation shows that the various principles of mill action make fuels of different fineness. The hammer mills produce relatively coarse coal with but little superfines, the roller mills produce widely differing fineness depending upon specific mill action and upon plant conditions, and the tube mills normally produce coal low in sieve mesh and high in superfines.

Air-classifying schemes are shown to vary greatly, there being room for much development with most mills. The author's turbidimetric method for measuring superfines is described.

UNIT SYSTEM OF COAL PULVERIZERS FOR THE GENERATION OF STEAM. By John Blizard. [Paper No. FSP-50-61]

Simplicity of the unit system is considered the principal feature by the author. Accurate supply of coal to the furnace requires a carefully worked-out system for regulating the flow of coal to the mill. One satisfactory method is by use of a rotating feed table, with a sleeve above it arranged so that movement of the sleeve will vary the area across which the coal flows on the feed table.

Pulverizers used with such a system must be of rugged construction to prevent failure. To obtain correct mixture, coal and air must be mixed thoroughly before the stream is divided. In the conduits conveying the coal and air to the burners, the velocity of the mixture must be maintained to prevent separation.

THE NEED FOR COAL RESEARCH. By F. R. Wadleigh. [Paper No. FSP-50-62]

While there is great activity in coal research, the author stresses the need for still more attention and investigation in five main fields. These are: (1) the formation and occurrence of coal, (2) the constitution of coal, (3) the production of coal, (4) the utilization of coal, and (5) economics. Research is expensive but the results obtained in increased markets, stabilization, conservation, and in higher standards of operation will pay large interest on the money expended. Chemists and engineers express the opinion that many of the present methods of using coal are a waste of the raw material and are sure to be eliminated soon.

DETERMINATION OF ECONOMIC VALUE IN THE SELECTION OF POWER-PLANT EQUIPMENT. By F. M. Van Deventer. [Paper No. FSP-50-63]

After reviewing the customary procedure in obtaining competitive bids on equipment, the author discusses critically the commonly used criteria of relative value. Definite conclusions are drawn concerning the correctness and merit of each. Two illustrative examples are presented to demonstrate the author's conclusions, and the recommended method is summarized.

BOILER-FURNACE REFRACTORIES. By C. F. Hirshfeld and W. A. Carter. [Paper No. FSP-50-64]

A field survey of the conditions to which refractories were subjected in different kinds of service was made along with laboratory investigations such as analyses of fuel and petrographic study of new and used refractories. The work had as its object the determination of the chemical and physical phenomena occurring in boiler-furnace refractories to work out data to aid in choice of firebrick for specific purposes. Each type of furnace construction, each method of firing, each variety of fuel, and each set of operating conditions calls for a unique solution.

STOKER ADVANTAGES AND DISADVANTAGES. By Theodore Maynz. [Paper No. FSP-50-65]

Use of draft gages and automatic furnace-draft regulators are considered a necessity by the author for proper operation of forced-draft stokers. Best results will be obtained by letting the operator adjust the stoker speed. Furnace volumes for a given rating are less for stokers than for other types of fuel-burning equipment. Failures occur most frequently from too small stokers for the coal, rating, and plant conditions. Low efficiencies, selected fuel requirements, operating difficulties, and liability to smoke have practically limited natural-draft overfeed stokers to a few special applications.

Multiple-retort underfeed stokers can burn efficiently nearly all types of bituminous coals. When all factors are considered, they are cheaper to install under large boilers for high outputs and efficiencies than other types of high-duty stokers. Their main disadvantages are overselling and under-installation.

PULVERIZED-COAL FIRING OF MARINE WATER-TUBE BOILERS. By T. B. Stillman. [Paper No. FSP-50-66]

Tests tend to indicate that if satisfactory operating results are to be secured in using pulverized coal in the smaller furnaces available in marine practice, it is imperative that the fusing point of the ash in the coal burned be above the flame temperatures existing near the walls and boiler tubes and that the coal be finely pulverized.

THE ECONOMIC STATUS OF OIL AS A FUEL FOR MARINE SERVICE. By George Atwell Richardson. [Paper No. FSP-50-67]

There have been no developments in oil-burning equipment for two or three years. Reasonable furnace efficiencies have been reached, and no great incentive exists for improving equipment. What has been accomplished has been in furnace design. Despite its advantages, oil is not capable of universal adoption from an economic standpoint.

RAILWAY PRACTICES IN UTILIZATION AND CONSERVATION OF OIL. By J. N. Clark. [Paper No. FSP-50-68]

In this paper the author mentions the growing competition of the airplane and motor vehicle and the manner in which the railroad is preparing to counteract that competition. Improvement in service, faster schedules, finer equipment, and safer and more efficient operation are among the most important steps taken by the roads. Fuel being the major item of expense, there is naturally a special effort to effect economy. This paper deals with oil fuel and the methods employed by the railroads in its utilization. Early experiments are mentioned and a short treatise on production is given. The specifications laid down by the railroads are also given. Then follow discussions of methods of delivery and storage, fire hazard, locomotive equipment for the handling of the oil, such as heating, etc., methods of firing, construction of combustion space, refractories employed, etc. Some of the advantages of oil over other forms of fuel are also given. The final portion of the paper is devoted to a discussion of recent improvements in railroad power equipment, fuel-economy devices, increase in locomotive runs, and stationary boilers.

SELECTION AND USE OF FUELS IN LOCOMOTIVE PRACTICE. By Malcolm Macfarlane. [Paper No. FSP-50-69]

This paper discusses the value to railroads of keeping fuel-performance records. The future will witness particular advancement in selection and use of fuels for locomotives. Performance figures are of great value as they show the way to savings in use of fuel. Excellent results are obtained by extra measures for supervision and training of firemen. Railroad systems in the United States use more fuel coal than any other single industry, so methods for effecting economies are particularly important.

DEVELOPMENT AND RECENT DESIGN OF STOKER-FIRED EQUIPMENT FOR STEAM GENERATION. By Joseph G. Worker and Joseph S. Bennett. [Paper No. FSP-50-70]

The authors outline the fundamental principles for burning coal and discuss developments that help improve the situation by stoker firing. Various methods of feeding fuel uniformly to the stoker are enumerated, and the importance of a wide range in the rate of feeding is stressed. The efficiency and capacity of a unit are affected greatly by proper air distribution. This must be uniform throughout the width of the stoker or unbalanced burning will result.

Protection of the walls surrounding a stoker is receiving increased attention. The saving with proper furnace enclosure is great. Preheated air is of benefit in underfeed-stoker firing, as so large a portion of the fuel bed is supplied with green coal rising from the bottom of the retorts, that use of highly preheated air is logical. Developments in stoker-fired plants are not affecting maintenance of stoker parts. Although preheated air has been used, by redesigning parts, many times greater cooling surface is provided than has been used heretofore, which has offset the effort of high temperature.

Progress in Central-Station Use of Pulverized Coal. By E. H. Tenney. [Paper No. FSP-50-71]

Operating records of five pulverized-fuel-firing arrangements and furnace designs show what value lies in each, these depending upon the grade and price of coal used, the plant load factor, and the rate for fixed charges. The design best adapted shows a saving of $0.40 per ton of coal in operating costs and a saving of $2.44 in fixed charges, having been brought about by reduction in coal-preparation costs, general improvement in boiler economy, reduction in furnace maintenance by the use of water walls, elimination of hard slag in furnace by horizontal firing, and increase in ratings by the use of water walls, turbulent firing, and draft equipment. The nature of further improvements will be difficult to forecast. Improvement of mills will probably depend upon development of new types and on present designs, in maintaining the fineness of grind, and greater facility for repairs. The problem of higher rates of heat liberation in the furnace is receiving attention. Water walls have about reached their limit with practically the entire furnace enclosed. The use of radiant superheaters as a part of furnace walls offers possibilities in obtaining a higher and more even superheat. Means for reducing the quantity of fly ash in the flue gases will be important where pollution of air is a severe local disadvantage. All these problems can be discussed to the greatest advantage if considered from a completely economical viewpoint.

Present Status of Furnace and Burner Design for the Use of Pulverized Fuel. By E. G. Bailey. [Paper No. FSP-50-72]

The ideal burner is one by which combustion of fuel can be accomplished in a furnace of minimum volume and with reasonably low excess air. The differences between the problems of burning oil and gas and pulverized coal are of relative magnitude rather than of principle, and hence the improvements in pulverized-fuel burners are following the lead of the gas and oil burners by having all the air for combustion enter with and adjacent to the fuel at the burner, with active turbulence and mixing. Pulverized coal is still more difficult to burn than oil.

The Relative Value in Locomotive Service of Different Sizes of the Same Coals. By John G. Crawford. [Paper No. FSP-50-73]

The paper deals with the comparative locomotive-fuel values of various grades (sizes) of coal from the same mine. It does not attempt to determine a formula which would be applicable to any grade of coal from any district, but summarizes such information as is obtainable from the various railroads and elsewhere. It deals in a general way with the characteristics of coals, their preparation, and their physical as well as chemical make-up, and with the effect of these factors on the condition of coal supplied to locomotives. It emphasizes the importance of making sure that the coals tested are representative as to size and quality, and that a sufficient number of tests are made with each grade of coal to secure a reliable average.

Railway Practice in Utilization and Conservation of Coal. By W. J. Overmire. [Paper No. FSP-50-74]

Detailing the organization that can make an effective cut in the cost of coal in passenger and freight service, and outlining the selection of grades suitable for a particular road's use, the railroad practices in the utilization and conservation of coal are stated to be: Selection and purchase of suitable coal. Maintenance of a high standard of preparation on all coal shipped. Distribution of the coal to reduce mixing to a minimum. Careful accounting for all coal purchased and statistics for analyzing the fuel performance. Locomotives of proper design and size. A high standard of maintenance of motive power, rolling stock, and track. Elimination of delays and slow orders. Adopting train loadings and train schedules for the most efficient movement of trains. Reducing grades and constructing double track and other facilities for improved operating conditions. Educating officials and employees and soliciting their assistance in the conservation of coal.

Damage Due to Smoke. By H. B. Meller. [Paper No. FSP-50-75]

The smoke investigation conducted by the Mellon Institute of Industrial Research of Pittsburgh forms the basis of the paper, with additional data and observations as the result of studies since that time. The smoke problem in cities arises mainly from the fuels that give off during combustion part of their volatile matter, fixed carbon, ash, and sulphur. Although coke and anthracite burn without appreciable smoke and are low in volatile matter, ash is carried off in proportion to the draft. The effects on buildings, vegetation, and health are summarized, and also the economic cost.

Smokeless and Efficient Firing of Domestic Furnaces—Part II. By Victor J. Azbe. [Paper No. FSP-50-76]

In this paper the author gives factors that govern smoke elimination and describes tests made on smoke-abatement devices and with different types of furnaces. To prevent smoke, there must be sufficient air present to burn all gases and vapors completely. Smoke once formed cannot be burned to any appreciable extent. Chemical activity is greater and combination of oxygen with the combustible quicker at high temperatures. A proper amount of air at the proper point will assure smokelessness. Too much air will do no good, and may cause harm by reducing furnace temperatures.

Problems and Methods in Smoke-Abatement Work. By H. K. Kugel. [Paper No. FSP-50-77]

The author presents some problems encountered and solutions reached in Cleveland's campaign against smoke. Some of the conclusions reached are that stoker firing is far superior to hand firing and that the smokeless boilers that made the most smoke had the smallest grate area in proportion to the rated capacity. Secondary air admission through a drop section is better than at any other point. Downdraft boilers made a good record. The percentage of violations turned up by a roving inspector was found to be three times as great as by a man at a fixed point.

Some Factors in Furnace Design for High Capacity. By E. G. Bailey. [Paper No. FSP-50-78]

The author gives the principal factors that should control furnace design as complete combustion with a minimum of excess air, controllable rate of combustion over a reasonable range, long endurance of furnace walls, prevention of slag on boiler tubes, and removal of ash. The tendency is to use water-cooling tubes, tied in as part of the circulating system of the boiler, to effect the cooling in different parts of the furnace walls or floors as needed. To burn a given quantity of fuel in a given time and keep each particle of fuel within the furnace a relatively long time requires a large furnace. As large furnaces are expensive, it is desirable to burn fuel at high rates of combustion.

High temperatures are conducive to rapid and efficient combustion, but as high temperatures destroy wall structures, proper control is necessary. Turbulence minimizes the volume of hot, opaque flame and makes the gases transparent more quickly, which permits furnace-wall temperatures to equalize by radiation, thus reducing damage from hot spots.

Floating particles of ash are difficult to deal with, especially when its fusing point is below the furnace-wall surface temperature. To burn coal having an ash of low fusing temperature at high rates of combustion requires some form of furnace cooling throughout all walls.

An Accurate Method for Measuring Steam. By Axel Härlin. [Paper No. FSP-50-79]

In this paper the author shows that when measuring the quantity of steam flowing through a pipe by means of a diaphragm, the method deduced and theoretically established by Odqvist is in regard to accuracy far superior to any other method.

However, as Odqvist's method requires that the pressure be taken out in a manner that makes the method difficult to use and jeopardizes the desired accuracy, a simple modification is indicated which, without appreciably affecting the accuracy, allows a convenient and reliable arrangement for the pressure connections. With this modified method a mean error of only about 1 per cent has to be reckoned with.

The relatively complicated formulas for steam flow are transformed by means of a diagram into a number of factors which, multiplied by each other, give the steam quantity. An approximate diagram is also given which, without further calculation, can be used in making rough estimates.

The paper concludes with a few instructions for carrying out the measurements.

A Graphical Method of Computing Boiler Heat Balance. By Eric Pick. [Paper No. FSP-50-80]

To avoid tedious calculations and the use of tables, the author has developed charts which make it possible to compute a boiler heat balance of the so-called short form quickly and without resorting to calculations. The charts presented may be used where various types of solid or liquid fuel are burned, but are not suitable for gaseous fuels. Charts are given for determining: heat value of fuel from ultimate analysis, carbon burned per pound of fuel, maximum CO_2 content, per cent by volume on dry basis from Orsat

readings, minimum air supply, excess air when combustion is complete and incomplete, weight of moisture in air, boiler efficiency, loss due to moisture in fuel, air and to water formed by combustion of hydrogen, loss due to dry chimney gases, to incomplete combustion of carbon, and to unconsumed combustible in refuse.

REFRACTORIES SERVICE CONDITIONS IN FURNACES BURNING FUEL OIL. Progress Report of the A.S.M.E. Special Research Committee on Boiler-Furnace Refractories. By R. A. Sherman, Edmund Taylor, and H. S. Karch. [Paper No. FSP-50-81]

In this report the range of values for the service conditions which govern the life of refractories in a furnace burning fuel oil with mechanical-atomizing burners has been determined and recorded. The maximum temperature measured in the furnace gases was not higher than has been measured in stoker- and powdered-coal-fired furnaces. Although the temperature in the area of flame impingement was higher than that of the gases, probably because of surface combustion, the temperature attained was not high enough to cause fusion of the refractory. The slag formed in the furnace was therefore the result of the fusion of the ash of the oil, but, because of its small amount, the slag did not cause severe erosion of the walls.

HYDRAULIC PAPERS

COMPUTATION OF THE TAIL-WATER DEPTH OF THE HYDRAULIC JUMP IN SLOPING FLUMES. By Robert W. Ellms. [Paper No. HYD-50-5]

This investigation deals primarily with the methods of computing the tail-water depth of the hydraulic jump when it is produced in sloping flumes. The author has developed two formulas for this calculation based upon the unpublished work of A. G. Levy and J. W. Ellms of the Cleveland Water Department, and of J. R. Fleming and the author in a thesis presented to Case School of Applied Science. In this paper are given a description and the data of the latter's thesis work, and certain data obtained by the two former investigators. From a study of the results of these experiments the author has drawn certain conclusions as to what takes place in the hydraulic jump when it is produced in sloping flumes, and attempts an explanation of this spectacular and baffling phenomenon.

NOTES ON "A NEW METHOD OF SEPARATING THE HYDRAULIC LOSSES IN A CENTRIFUGAL PUMP." By Michael D. Aisenstein. [Paper No. HYD-50-6]

The author here supplements his previous paper [HYD-50-2] with instructions for plotting in certain cases, accompanied by an illustrative example.

FRICTION IN DREDGE PIPES. By James H. Polhemus and John R. DuPriest. [Paper No. HYD-50-7]

This paper presents some information on pipe friction for dredge pipe of 29 in. inside diameter and with velocities up to about 20 ft. per sec. The data were obtained during some recent tests of large hydraulic dredge pumps, and on account of the large size of the pipe and the high velocities encountered it was thought worth while to present the information for the benefit of others engaged in dredge work.

An analysis is also given of the data showing how the equation for loss of head in pipe lines can be modified so as to give a constant friction factor as velocity varies, instead of having both velocity and friction factor vary in the equation.

FLOW OF WATER OVER A V-NOTCH. By Joseph Tarrant. [Paper No. HYD-50-8]

In this paper the author presents a formula for finding the flow of water over V-notches with angles ranging from 90 deg. down to 27 deg., which is based on the experimental results given in D. Robert Yarnall's paper on the "Accuracy of the V-Notch-Weir Method of Measurement," presented before the A.S.M.E. in December, 1926. He compares this formula, with others which have been proposed, checks it with data obtained by several investigators, and concludes that, within the range of angles specified, it will prove useful. An alignment chart based on the formula is given, from which discharges may easily be read off.

MATERIALS HANDLING PAPERS

MARINE TERMINAL OPERATION. By Willard C. Brinton. [Paper No. MH-50-11]

The author, after an extended study of the numerous classes of freight handled at a number of steamship piers, found that electric storage-battery trucks provided with a lift mechanism for use with separable platform bodies as well as a crane attachment, would best serve the purpose in view. Many illustrations of the use of these trucks are included in the paper.

THE HYDRAULIC HANDLING OF ASHES. By Arthur Mellor Quinn. [Paper No. MH-50-12]

The author outlines the advantages of the hydraulic method of handling ashes and enumerates designs in modern installations which retain all the advantages of earlier designs and eliminate their major disadvantages. He considers the handling of ash from pulverized-fuel furnaces, and also its final disposition after having been hydraulically accumulated into a central sump.

MODERN HANDLING METHODS OF RAILROAD TRANSPORTATION. By G. C. Woodruff. [Paper No. MH-50-13]

In this paper the author discusses the shipment of less-than-carload merchandise freight in containers and their handling at terminals by overhead cranes, lift trucks, and motor trucks. He also deals with containers for bulk freight such as brick, sand, etc., and briefly with the motor truck as a terminal adjunct.

NOTE: Those who have not registered in the A.S.M.E. Fuels and Steam Power, Hydraulics, and Materials Handling Divisions, whose papers are abstracted on this and the previous pages, and who desire copies of any of these papers, may obtain them by using the form given below.

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AIRPLANE ENGINES

Cowling. 20 Miles Faster, G. F. Vultee. West. Flying, vol. 5, no. 3, Mar. 1929, pp. 38-39 and 140, 5 figs. Explanation of aerodynamic principles of new cowling developed by National Advisory Committee for Aeronautics is given; discussion of difficulties already encountered in its application to record-breaking Lockheed Air Express which was flown by F. Hawks when he broke Pacific-Atlantic record; methods employed in overcoming these difficulties.

Design. LeBlond Sixty Aircraft Engine Composed of Small Number of Parts. Automotive Industries, vol. 60, no. 11, Mar. 16, 1929, pp. 440-412, 4 figs. Details of new airplane engine rated as developing 65 hp. at 1950 r.p.m.; design is such as to permit of parts being made up into sub-assemblies, which can be inspected before being assembled into complete engine; power plant has five cylinders with bore of $4^1/_8$ in. and stroke of $3^3/_4$ in., giving total piston displacement of 250.58 cu. in.; 222 lb. aggregate weight without fuel.

New Airplane Engines (Les nouveaux moteurs d'aviation, M. Lamé. Aérophile (Paris), vol. 37, nos. 1-2, Jan. 1-15, 1929 (Blue Sec.), pp. 20-26, 10 figs. Design trends in new airplane engines, both air and water-cooled, with reference to various constructions are described; air-cooled cylinder design; aluminum pistons and crankcases; cooling of exhaust valves is principal consideration in America and tulip valves have been adopted; valves controlled by rocker arms and tappets; increasing power rating of water-cooled engines; efforts to reduce vibration.

The In-Line Air-Cooled Engine, S. D. Heron. Soc. Automotive Engrs.—Jl., vol. 24, no. 4, Apr. 1929, pp. 376-385 and (discussion) 385-387, 18 figs. Frontal areas of radial and V-type airplane engines compared; how air can be applied to cylinders of in-line engines; advantages of upright and inverted engines, their engine mountings, cylinder design and valve gears discussed; problem of inlet distribution in inverted engine; simple method of gearing proposed; comparison of production problems of radial and in-line engines.

Heavy Oil. Injection Engines and Their Application to Aviation (Les moteurs à injection et leur application à l'aviation), Poincaré. Technique Aéronautique (Paris), vol. 19, no. 86, Dec. 15, 1928, pp. 194-213, 16 figs. Design of heavy-oil engines for airplanes is discussed and advantages compared with gasoline engine regarding reduction of fire hazard, simplified pipe lines, omission of magnetos and spark plugs, elimination of need for altitude correction, and economy of fuel; mechanical injection best solution; Maybach, Junkers, Acro-Bosch, Deutz, Daimler, Benz, and Koerting engines; heavy-oil engine will take place now occupied by gasoline engine in aviation.

Starters. Inertia Starters for Aero Engines. Flight (Lond.), vol. 21, no. 10, Mar. 7, 1929, pp. 181-182, 9 figs. Details of large range of Eclipse inertia starters manufactured in Great Britain by British Thomson-Houston Co., Coventry; starters are available for operation either by hand cranking or by electric motor; 12 volts standard for starters; aviation hand turning gear is described.

AIRPLANE PROPELLERS

Manufacture. The Duralumin Propeller, G. Svehla. Popular Aviation and Aeronautics, vol. 4, no. 3, Mar. 1929, pp. 48, 50, 52, 54 and 97, 10 figs. Advantages of duralumin propellers and procedure in manufacture blades for Army and Navy are outlined; practically all blades forged or rolled; forging of blade for two-piece propeller; aging to give added hardness to metal.

Testing. Full Scale Tests on a Thin Metal Propeller at Various Tip Speeds, F. E. Weick. Nat. Advisory Committee for Aeronautics—Report, no. 302, 1929, 14 pp., 11 figs. Investigation made to determine effect of tip speed on characteristics of thin-bladed metal propeller; propeller was mounted on VE-7 airplane with 180-hp. E-2 engine and tested in 20-ft. propeller research tunnel; effect of tip speed on propulsive efficiency was negligible within range of tests, which was from 600 to 1000 ft. per sec. (about 0.5 to 0.9 velocity of sound in air).

Full-Scale Wind-Tunnel Tests of a Series of Metal Propellers on a VE-7 Airplane, F. E. Weick. Nat. Advisory Committee for Aeronautics—Report, no. 306, 1929, 18 pp., 13 figs. Adjustable blade metal propeller tested at five different angle settings, forming series varying in pitch; propeller mounted on Ve-7 airplane in 20-ft. N.A.C.A. propeller research tunnel; efficiencies found to be from 4 to 7 per cent higher than those of standard wood propellers operating under same conditions; results given in convenient form for use in selecting propellers for aircraft.

AIRPLANES

Brakes. Pneumatic Braking and Control of Rolling Airplanes (Druckluft-Bremsung und-Steuerung rollender Flugmaschinen), T. Kollinek. Motorwagen (Berlin), vol. 32, no. 6, Feb. 28, 1929, pp. 125-128, 4 figs. Requirements of brakes for heavy, high-speed airplanes; details of Knorr pneumatic control and brake for aircraft, and results of tests carried out by Junkers with this brake.

Control, Automatic. Mechanical Control of Airplanes, H. Boykow. Nat. Advisory Committee for Aeronautics—Tech. Memorandums, no. 504, Mar. 1929, pp. 1-11 and (discussion) 11-25, 10 figs. Fundamental conditions for automatic control for airplanes are discussed with description of automatic-control mechanism; first part is negative-pressure indicator, second and third part forming gyroscope consisting of two numerically equal gyroscopic tops coupled together but revolving in opposite directions; obtaining maximum steering economy; comments by Drexler, Bader and Diemer. From 1927 Yearbook of Wissenschaftliche Gesellschaft fuer Luftfahrt.

Helicogyre. The Helicogyre, V. Isacco. Flight (Lond.), vol. 21, no. 12, Mar. 21, 1929, pp. 244-245 and (discussion) 245, 3 figs. Details of Helicogyre invented by author are given; rotation of wings caused not by air forces on them, as in Cierva Autogiro, but by propellers driven by engines mounted on main wings; weight lifted per horsepower; safety. Abstract of paper presented before Roy. Aeronautical Inst.

Maximum-Safety. Maximum Safety Planes. Aviation, vol. 26, no. 13, Mar. 30, 1929, p. 963, 1 fig. Details of two cabin monoplanes having similar design characteristics, but differing in dimensions and carrying capacity, which have been developed by Maximum Safety Airplane Co., Los Angeles; one model is two-place training plane and other four-place craft with passengers' cabin located abaft pilot's cockpit and means of communication provided between two; both are powered with Comet 150-hp. seven-cylinder radial air-cooled engines.

Manufacture. Cost and Quantity in Airplane Manufacturing, L. C. Milburn. Soc. Automotive Engrs.—Jl., vol. 24, no. 3, Mar. 1929, pp. 270-272, 1 fig. Actual quantity-cost curve is irregular because improved materials, tools, and methods for fabrication made sudden changes when introduced; tendency to adopt pressed-steel construction in place of wood and welded-steel tubing for quantities that justify tool cost; amount of floor space influences manufacturing cost; interrelation of design, tooling and labor costs.

Some Aspects of the Production Problem in Aircraft, F. Sigrist. Royal Aeronautical Soc.—Jl. (Lond.), vol. 33, no. 219, Mar. 1929, pp.

NOTE.—The abbreviations used in indexing are as follows:
Academy (Acad.)
American (Am.)
Associated (Assoc.)
Association (Assn.)
Bulletin (Bul.)
Bureau (Bur.)
Canadian (Can.)
Chemical or Chemistry (Chem.)
Electrical or Electric (Elec.)
Electrician (Elecn.)
Engineer (Engr.[s])
Engineering (Eng.)
Gazette (Gaz.)
General (Gen.)
Geological (Geol.)
Heating (Heat.)
Industrial (Indus.)
Institute (Inst.)
Institution (Instn.)
International (Int.)
Journal (Jl.)
London (Lond.)
Machinery (Machy.)
Machinist (Mach.)
Magazine (Mag.)
Marine (Mar.)
Materials (Matls.)
Mechanical (Mech.)
Metallurgical (Met.)
Mining (Min.)
Municipal (Mun.)
National (Nat.)
New England (N. E.)
Proceedings (Proc.)
Record (Rec.)
Refrigerating (Refrig.)
Review (Rev.)
Railway (Ry.)
Scientific or Science (Sci.)
Society (Soc.)
State names (Ill., Minn., etc.)
Supplement (Supp.)
Transactions (Trans.)
United States (U. S.)
Ventilating (Vent.)
Western (West.)

207–218 and (discussion) 218–225, 8 figs. Production as applied to airplanes is discussed; experimental production; before issue of production drawings there should be discussion between all concerned, at which data of liaison officer will prove useful; purpose for which machine is required must decide main constructional features; selection of material; methods of Hawker Engineering Co. on main details of construction; types of ribs and spars.

Seaplane. American Marchetti Seven-Passenger Flying Boat. Airway Age, vol. 10, no. 4, Apr. 1929, p. 518, 1 fig. Details of seven-passenger cabin biplane Savoia-Marchetti S-62 to be manufactured in United States by American Aeronautical Corp.; 500-hp. American-built pusher-type engine; concave bottom hull of two-ply cedar and from water line up is plywood fabric covered; wing span 50 ft. 10 in.; maximum speed 134 m.p.h.; landing speed 53 m.p.h.; glass inspection holes in hull and wing.

Spinning Characteristics. Analysis of Flight and Wind-Tunnel Tests on Udet Airplanes With Reference to Spinning Characteristics (Low-Wing Udet U 6, Udet U 7 "Kolibri," Udet U 12 "Flamingo.") (Auswertung von Flugversuchen und Windjanalmessungen an den Udet-Flugzeugen), H. Herrmann. Zeit. fuer Flugtechnik und Motorluftschiffahrt (Munich), vol. 20, no. 1, Jan. 14, 1929, pp. 3–15, 21 figs. Results of tests with light biplane, high-wing monoplane, and low-wing monoplane discussed; systematic spinning tests using two rudders, one enlarged backward and other upward; wind-tunnel tests; comparison of inertia forces in spinning with aerodynamic longitudinal or pitching moment.

ALLOY STEEL

Castings. Alloy Cast Steels, D. Zuege. Am. Foundrymen's Assn.—Preprint, for mtg. Apr. 8 to 11, 1929, pp. 361–384, 6 figs. Data relating to alloy steels adapted to foundry use are given; classification of alloy-steel castings; characteristic effects of chromium, nickel, manganese, vanadium, and molybdenum upon structure of steel; comparison of chrome-nickel and manganese-carbon steel; proportional cost increase for high-alloy steels is greater than actual increase in cost of alloys used.

Heat Treatment. Dangerous Heat Treatments. Mech. World (Manchester), vol. 85, no. 2202, Mar. 15, 1929, pp. 243–244. Specific laws which govern heat treatment of every alloy and steel are discussed; correct annealing or normalizing of mild steel; precautions in tempering, forging, case-hardening, carbonizing high-speed-steel tools; results of neglect of time element in heat treatment of gun recoil springs.

Properties. Welding Facts and Figures, D. Richardson and E. W. Birch. Welding Jl. (Lond.), vol. 26, nos. 304 and 305, Jan. and Feb. 1929, pp. 6–9 and 38–40. Jan.: Characteristics of alloy and special steels are discussed; theory of ternary steels and their structures; special elements which modify position of critical points and temperatures required for annealing and hardening. Feb.: Properties and methods of welding, hot working, and pickling are described; particulars of series of alloys made by Central Alloy Steel Corporation of America.

ALLOYS

Aluminum. See ALUMINUM ALLOYS.

Brass. See Brass.

ALUMINUM

Welding. Forged Aluminium Welds. Welding Jl. (Lond.), vol. 26, no. 304, Jan. 1929, p. 12. Process applied to heavy sheets, which consists in heating edges to be joined by means of oxyacetylene flame and hammering, and thus welding them together, while they are in semi-pasty condition, briefly described; disadvantages; exact temperature of tremendous importance; fusion welding of aluminum. From Revue de la Soudure Autogène.

ALUMINUM ALLOYS

Age Hardening. The Age-Hardening of Some Aluminum Alloys, M. L. V. Gayler and G. D. Preston. Inst. of Metals—Advance Paper (Lond.), no. 489, for mtg. Mar. 13–14, 1929, 43 pp., 22 figs. Physical properties of five typical aluminum alloys containing copper, magnesium silicide, or both, have been examined under similar conditions of heat-treatment; Brinell hardness, tensile strength density, and electric conductivity; changes in crystals as determined by X-ray analysis; precipitation from solid solution entails two processes which are considered.

Aluminum Bronze, Casting. Aluminum Bronze Cast in Permanent Molds, W. R. Williams. Am. Mach., vol. 70, no. 13, Mar. 28, 1929, pp. 503–504, 2 figs. Methods employed by Westinghouse Electric and Mfg. Co. for casting parts weighing up to 7 lb. and of wide variety of shapes, using alloy with small percentage of iron; sectional molds not desirable because of spreading at joints.

Welding. Welding Aluminum and Its Alloys, W. M. Dunlap. Aviation, vol. 26, no. 11, Mar. 16, 1929 (Aeronautical Eng. Sec.), pp. 40 and 45–51, 13 figs. Information regarding fusion welding aluminum and its alloys is given; selection or tip size important; most effective method of removing oxide film; choice of welding metal; working speed greater than with steel; progressive tack welding necessary; flux should be used for castings.

ASH HANDLING

Hydraulic. The Hydraulic Handling of Ashes, A. M. Quinn. Power House (Toronto), vol. 23, no. 4, Feb. 20, 1929, pp. 40–42. Early installations are described; designs employed in modern installations; handling ash from pulverized-fuel furnaces; ash disposal.

Steam Power Plants. Selecting a Coal and Ash Handling System for the Small Plant, W. G. Plehn. Power, vol. 69, no. 14, Apr. 2, 1929, pp. 547–548, 2 figs. In small steam power plant layout of coal and ash-handling equipment is restricted by initial cost, space available, capacity, labor necessary, and operation costs; simple system of monorail clamshell with low overhead coal bunkers and drag-chain conveyor for ashes meets all requirements of small plant under consideration.

AUTOMOBILE ENGINES

Camshafts, Machining. Camshaft Production. Automobile Engr. (Lond.), vol. 19, no. 252, Mar. 1929, pp. 104–106, 6 figs. Recent improvements in equipment for machining automobile and aircraft camshafts are discussed; details of Melling cam-turning multi-cut lathe, Werner cam-grinding machine, Worton grinder for machining airplane engine cams, three-spindle deep-hole drilling machine of Craven Brothers, Werner camshaft-testing machine, and Werner deep-hole drilling machine.

Carburetors. Thermostatic Control of Mixture, M. R. Wolfard. Soc. Automotive Engrs.—Jl., vol. 24, no. 3, Mar. 1929, pp. 352–353. Description of carbureters with special reference to thermostatic control; auxiliary air-valve type carburetor generally found to give greatest mileage per gallon of fuel; thermostatic control devices.

Cylinders. Desirability of a Large-Bore Engine, A. Taub. Soc. Automotive Engrs.—Jl., vol. 24, no. 3, Mar. 1929, pp. 282–285 and (discussion) 268–289, 8 figs. Large bore design offers good engine that has maximum performance over longest period, and that can be produced most easily and at lower cost; it has also better cylinder-blocks, better crankshafts for less cost, and present greater opportunity for further development than does small-bore long-stroke engine.

Diesel. See DIESEL ENGINES.

Heavy-Oil. Heavy-Oil Engine for Rail and Road, A. E. L. Chorlton. Modern Transport (Lond.), vol. 21, no. 522, Mar. 16, 1929, p. 8. Characteristics of compression-ignition engines; limitations of oil engines compared with ordinary gasoline engines; important factors in weight increase of Comig engine; competitive design; oil engine for railway work; regulation and control; road tests; comparative costs. Abstract of paper read before Instn. Automobile Engrs.

Ignition. Ignition Requirements for High-Compression Engines, J. T. Fitzsimmons. Soc. Automotive Engrs.—Jl., vol. 24, no. 3, Mar. 1929, pp. 306–313 and (discussion) 313–314, 15 figs. Exactions imposed on distributor by engine torsional vibration; need of automatic spark-advance mechanism in distributor; peculiar conditions in some engines caused by non-homogeneous mixture surrounding spark plugs; difficulties arising from shrinkage of materials; influence of high-compression engine on design of distributor cam and circuit-breaker lever; oscillograph studies of circuit-breaker action.

Springs. New Spring Design Eliminates Center-Bolt Hole. Automotive Industries, vol. 60, no. 12, Mar. 23, 1929, p. 478, 3 figs. Brief description of method of locating springs on axles or in trunnion blocks introduced by Jonas Woodhead and Sons, Leeds, England, which is finding favor among British truck and bus manufacturers; spring consists of dividing main leaf at center, forming eyes at adjacent ends, and utilizing transverse bolts, special top clamping plate, or slots in trunnion block to locate eyes.

Peculiar Phenomena in Automobile Transverse Springs (Eigenartige Erscheinungen an Automobil-Querfedern). Motorwagen (Berlin), vol. 32, no. 4, Feb. 10, 1929, pp. 67–68, 5 figs. Results of investigations of fractures which occurred in front springs, taking into consideration design, manufacture, and properties of material employed; defects were found in method of construction and in chemical composition of metal employed.

Supercharging. Effect of Exhausting Into Rarefied Atmosphere, C. Waseige. Automotive Industries, vol. 60, no. 11, Mar. 16, 1929, p. 452. Advantages of supercharging for both automobiles and for airplanes flying at high altitudes briefly discussed; results of recent laboratory test in which increase in power output of 22 per cent was obtained by exhausting into partial vacuum. Abstract of paper presented before Soc. Française de Navigation Aerienne.

AUTOMOBILE PLANTS

France. Citroen Keeps Pace With American Mass Production, W. F. Bradley. Automotive Industries, vol. 60, no. 12, Mar. 23, 1929, pp. 472–475, 4 figs. Description of plants of Andre Citroen Co., Paris, and methods of manufacture; $6,000,000 expended to improve plant and obtain new machinery, 97 per cent of which was purchased in United States; orders placed for additional $2,000,000 worth of equipment; Company engineers keep watch on developments here and quickly adapt them to Company's system.

Foundries. Automobile Foundry Pours Aluminum Castings on a Conveyor, P. Dwyer. Foundry, vol. 57, no. 6, Mar. 15, 1929, pp. 222–227 and 230, 12 figs. Description of new aluminum foundry of Packard Motor Car Co., Detroit and methods employed there; two conveyor units on which all molds are assembled and poured; complete sand handling outfit prepares sand and keeps it in circulation; extensive monorail system for handling metal and molds; two large reservoir furnaces and six tilting pot furnaces.

Laboratories. Chrysler Engineering Department, C. A. McGroder. Iron Age, vol. 123, nos. 12 and 13, Mar. 21 and 28, 1929, pp. 801–803 and 876–878, 11 figs. Mar. 21: Description of laboratories of Chrysler Motors at Highland Park plant where laboratory tests are large feature of manufacture; margin of safety insured by extreme tests to which experimental parts are subjected; two machines for testing shock absorbers. Mar. 28: Discussion of shock, torsion, and bursting rests; chemical, metallurgical, and electrical laboratories, and testing apparatus are described.

Materials Handling. Cost of Cylinder Block Machining Reduced by Graham-Paige Through Lessening of Manual Handling, A. F. Denham. Automotive Industries, vol. 60, no. 11, Mar. 16, 1929, pp. 434–438, 6 figs. Description of conveyors, hoists, and straddling machines used in machining line for engine blocks of smaller cars, which is designed to handle 256 units per day; location of all machining operations from part to which they are most closely related.

You Can Handle Diverse Products Mechanically, L. Ruthenburg. Factory and Indus. Mgmt., vol. 77, no. 3, Mar. 1929, pp. 459–461 and 480, 4 figs. Mechanical handling methods of work in process used by General Motors Truck Corp., Pontiac, Mich., when problem is one of job shop building motor truck, buses, and taxicabs to customers' specifications.

AUTOMOBILE MANUFACTURE

France. The Manufacture of the Citroen Car. Machy. (Lond.), vol. 33, nos. 857 and 858, Mar. 14 and 21, 1929, pp. 749–757 and 781–788, 34 figs. Mar. 14: Production methods and organization of Citroen Works, Paris, are described; factory arrangements; foundry; working arrangements; drop forging shop; pressed steel shops; machine and assembly shops; engine assembly. Mar. 21: Operations on cylinder block; continuous milling operations; drilling locating holes; cylinder boring; multi-spindle drilling; sensitive drilling operations; reaming camshaft and main bearings.

Production Costs. How the Ford Company Gets Low Production Costs, J. Younger. Soc. Automotive Engrs.—Jl., vol. 24, no. 4, Apr. 1929, pp. 401–404. Discussion of paper previously published in Dec. 1928 issue of Journal is given with brief abstract of paper; workmen's operations require no thought; system's relation to model and market; question of whether industry uses enough automatic machines; importance of continuous operation.

AUTOMOBILES

Air Resistance. Air Resistance of Automobiles, E. H. Lockwood. Am. Highways, vol. 8, no. 2, Apr. 1929, pp. 1–4. Results of four series of air-resistance measurements carried out during past eight years in Germany and United States; rolling resistance and air resistance of sedans, coupes, roadsters, and touring cars of various makes on different grades.

Brake Linings. Modern Friction-Materials, J. Sneed. Soc. Automotive Engrs.—Jl., vol. 24, no. 3, Mar. 1929, pp. 298–299 and (discussion)

300–305. Main objections to high friction coefficients are rapid wear, greater liability to cause scoring, and instability; molded lining usually reaches its full efficiency after about 300 mi. of service; it resists oil to marked degree and, after it has been running in oil for some time, it can be successfully restored by washing in clean gasoline.

Clutches. Automatic Clutch Control. Motor Transport (Lond.), vol. 48, no. 1251, Mar. 4, 1929, p. 243, 1 fig. Details of German Erdelen device designed to simplify motor vehicle driving; device consists primarily of suction cylinder similar to that used in well-known Dewandre servo-brake unit; cylinder head is connected to engine manifold and piston to clutch lever, control being effected by rotary valve coupled to accelerator.

N.A.G. Automatic Clutch (kupplungsautomat der NAG-Werke), J. Lipschitz. Motorwagen (Berlin), vol. 32, no. 4, Feb. 10, 1929, pp. 69–72, 6 figs. Details of clutch employed in passenger car Type NAG-Protos; automatic action is effected by introduction of centrifugal force in play of coupling process; centrifugal force is not directly used for producing surface pressure, but only to free ordinary pressure springs of clutch, after which it works in same way as any other disk or lamellar clutch.

AUTOMOTIVE FUELS

Detonation. Determination of Detonation Ratings, G. G. Brown. Oil and Gas Jl., vol. 27, nos. 41 and 42, Feb. 28, and Mar. 7, 1929, pp. 156, 158, 160 and 162, 107–108 and 157, 10 figs. Feb. 28: Discussion of research work undertaken at University of Michigan, on detonation of motor fuels and determination of knock ratings. Mar. 7: Volatility in motor fuel performance; relative importance of points both above and below 50 per cent point in Am. Soc. Testing Matls. distillation.

Future. Fuels of the Future, W. F. Bradley. Autocar, vol. 62, no. 1738, Feb. 22, 1929, pp. 373–374, 2 figs. Possibility of high-speed automotive Diesel engine using gas oil, which is from 60 to 80 per cent cheaper than gasoline, is discussed; details of Sauer 6-cylinder automotive Diesel engine; France in seeking alternatives to gasoline, has proved value of producer gas; use of methane gas and other fuels.

Gas. Fueling Motor Buses With Compressed Gas (Alimentation des autobus par les gaz comprimés ou non), E. Marcotte. Revue Industrielle (Paris), vol. 59, no. 2234, Jan. 1929, pp. 16–22, 14 figs. Comparison of systems; gases suitable for purpose; generation and compression; storage; wood and charcoal gas producers.

Methanol, Synthesis of. Synthesis of Methyl Alcohol (Contribution a l'étude de la synthèse du méthanol), E. Audibert. Chimie et Industrie (Paris), vol. 20, no. 6, Dec. 1928, pp. 1015–1022. See brief translated abstract in Chem. and Industry (Lond.), vol. 48, no. 9, Mar. 1, 1929 (Abstract Sec.), p. 162. Résumé of work carried out by author on synthesis of methyl alcohol from carbon monoxide and hydrogen under high pressure. Presented at Conference on Bituminous Coal, Pittsburgh, 1928.

B

BEARINGS, JOURNAL

Lubrication. Coefficients of Friction of Journal Bearings With Imperfect Lubrication (Die Reibungsverhaeltnisse des Gleitlagers bei unvollkommener Schmierung), W. Koehler. Bergmann Mitteilungen (Berlin), vol. 7, no. 1, Jan. 1929, pp. 21–23, 8 figs. Lubricant-testing apparatus of Dittmar is described; measurements of momentary revolving speeds and consequently retardation curves are accomplished by optical photographic means; retardation and frictional coefficients.

BOILER FURNACES

Air Preheating. Air Preheating in Boiler Furnaces (Die Luftvorwaermung bei Rostfeuerungen), W. Gumz. Feuerungstechnik (Leipzig), vol. 17, nos. 3 and 4, Feb. 1 and 15, 1929, pp. 25–28 and 38–43, 9 figs. Notes on value of air preheating; phenomena occurring in fuel bed; temperature-limiting factors; danger of coking; fusion point of slag and other slag influences; influence of temperature on grate, grate material, and mechanical operation of furnace; comparison of grate system from standpoint of air preheating; highest permissible temperature.

Rotary. The Atkinson Rotary Furnace and Inclined Grate for Steam Boilers, J. S. Atkinson. Engineering (Lond.), vol. 127, no. 3295, Mar. 8, 1929, pp. 311–313, 9 figs. Furnaces described incorporate entirely new method of carrying out combustion, and author believes that results which have been obtained under every-day working conditions have definitely established great importance and value of this system; results of experiments conducted in Glasgow. Paper read before Bradford Eng. Soc.

BOILERS

Control. The Hagan System of Automatic Boiler Control. Engineering (Lond.), vol. 127, no. 3293, Feb. 22, 1929, pp. 247–248, 2 figs. Principal results of change-over to automatic control; brief description of system; four Babcock and Wilcox boilers each of 13,000-lb. per hour evaporate capacity in plant; these have chain-grate stokers driven by steam engine and have independent dampers at boiler exits; comparative results of boiler plant with automatic control are given in table.

Heat Balance. Graphical Interpretation of Heat Balance of Boilers (Interpretation Graphique des Bilans Thermiques des Chaudières), J. Peltier. Genie Civil (Paris), vol. 94, no. 12, Mar. 23, 1929, pp. 289–290, 3 figs. Criticism of Sankey diagram; author proposes original graphical analysis of heat balance and variations in output.

High-Pressure. Drumless Boilers, D. S. Jacobus. Boiler Maker, vol. 29, no. 2, Feb. 1929, p. 53, 2 figs. Series boiler was one step in development of Calumet boiler and use of higher pressures led Babcock and Wilcox Co. to make experiments in drumless boiler provided with forced circulation; series boiler is name given to first of this type tested; boilers were arranged to have comparatively no frictional resistance to flow of steam and water. Abstract of address before Engrs. Soc. West. Pa.

Steam Generation at High Pressures and Temperatures, S. Loeffler. Power, vol. 69, nos. 12 and 13, Mar. 19 and 26, 1929, pp. 486–489 and 524–527, 13 figs. Mar 19: Argument for superiority of Loeffler steam-pumping boiler over other existing types for such service; standard boilers for high pressure; double-fluid boilers. Mar. 26: Description of actual and projected installations and reports of results obtained; triple-feed pumps; superheat is stabilized; adaptability to space.

Locomotive. See LOCOMOTIVES, Boilers.

Pulverized - Coal - Fired. Pulverized - Fuel Boiler Tests at the Calumet Station, Chicago. Engineering (Lond.), vol. 127, no. 3292, Feb. 15, 1929, p. 217. Tests made on pulverized-fuel boilers are described and results tabulated; three series of tests were made, fuel used being Central Illinois (Kincaid), Perry County (Kentucky), and Youghiogheny coals.

BRASS

Research. Curves for Computing Strength of Complex Brasses, O. W. Ellis. Iron Age, vol. 123, no. 11, Mar. 14, 1929, pp. 740–741, 13 figs. Approximate effect of each of several alloying elements made from study of physical properties of 50 or more special makes and analysis of other publications on complex brasses are shown in diagrams. Abstract of paper presented before Inst. of Metals.

C

CADMIUM PLATING

Rust Prevention by. Cadmium Plating as a Rust Preventive, P. Sievering. Am. Mach., vol. 70, no. 11, Mar. 14, 1929, pp. 425–426. Discussion of why cadmium plating is being used more frequently as rust preventive for machine parts, and how plating is done in contract shop; thin coat of cadmium is less expensive and more effective rust preventive than grease, and is one of easiest metals to electroplate.

Electro-Deposition of Cadmium for Rust Prevention, S. Wernick. Metallurgist (Supp. to Engineer, Lond.), Mar. 1929, pp. 36–38. Notes on composition of solutions; electrode-efficiency ratio; effects of variations in composition of solution; properties of deposit; composite deposits; mechanical properties. Review of paper read before Electroplaters and Depositors' Tech. Soc.

The Electrodeposition of Cadmium for Rust Prevention, S. Wernick. Metal Industry (Lond.), vol. 34, no. 10, Mar. 8, 1929, pp. 245–248 and (discussion) no. 11, Mar. 15, pp. 277–280. Wide divergence exists in composition of cadmium-plating solutions recommended by different authorities; electrode efficiency ratio; effects of variations in composition of solution by increasing cadmium content, temperature and current density; throwing power of solution; use of cadmium plating as under-coating to more pleasing finishes of less protective capacity. Read before Electroplaters' and Deposits' Tech. Soc.

CARS

Dynamometer. Nothern Pacific Dynamometer Car. Ry. Mech. Engr., vol. 103, no. 3, Mar. 1929, pp. 126–130, 5 figs. New car, built at Como shops, records drawbar pull up to 250,000 lb.; large living quarters provided.

CAST IRON

High-Test, Manufacture of. High-Test Gray Cast Iron—European Developments, E. E. Marbaker. Am. Foundrymen's Assn.—Preprint, for mtg. Apr. 8 to 11, 1929, pp. 405–416. European methods of producing high-test grey cast iron are discussed; decrease of carbon content; control of cooling rate after casting; reduction of particle size of graphite and improvement distribution; superheating; rapid cooling of high silicon iron; treatment with calcium silicide; alloying with elements such as nickel and chromium; agitation of molten iron; eutectic cast iron.

Properties. Properties of Cast Iron of Interest to the Metallurgist, Founder, and Engineer. Am. Foundrymen's Assn.—Preprint, for mtg. Apr. 8 to 11, 1929, pp. 331–342. Report of Subcommittee on Research of Committee on Gray Cast Iron; details of causative, formative, and effective properties of gray cast iron which are listed to serve as measuring stick for cast iron; status of present methods of testing properties; most unsatisfactory test in this whole group is determination of graphite with subsequent estimation of combined carbon by difference.

CHAIN DRIVE

Roller - Chain and Chain - Gear. Roller Chain and Chain-Gear Drives (Rollenkettengetriebe und Zahnkettengetriebe), E. Geister. Maschinenbau (Berlin), vol. 8, no. 4, Feb. 1, 1929, pp. 112–116, 21 figs. Attempt to improve position which chain drives take in mechanical transmission; for high speeds, not roller chains but chain gears, would be justified.

CHROMIUM-NICKEL STEEL

Castings. High - Grade Chromium - Nickel Steel Castings (Ueber hochwertigen Chrom-Nickel-Stahlguss), V. Zsak. Giesserei (Duesseldorf), vol. 16, no. 9, Mar. 1, 1929, pp. 193–205, 38 figs. Historical review of research and results of author's investigations; tests were carried out on annealed and treated specimens; in author's opinion this steel is best-casting material which is likely to be available for some time to come.

Heat-Treated, Compression Strength of. The Stress-Strain Diagrams of a Heat Treated Nickel-Chrome Steel, A. Robertson and A. J. Newport. Metallurgist (Supp. to Engineer, Lond.), Feb. 22, 1929, pp. 23–26, 4 figs. Results of compression tests made on tubes $1^1/_4$-in. diam., 18 gage, supplied by Superintendent of Royal Air Force; approximate chemical composition was carbon 0.25, nickel 4.1, chromium 1.25.

COAL HANDLING

[See Ash Handling.]

COOLING TOWERS

Improved Designs. Cooling Towers. Ferro-Concrete (Lond.), vol. 20, no. 9, Mar. 1929, pp. 197–212, 8 figs. partly on supp. plates. Improved methods of design and construction; advantage of large units; rectangular towers; polygonal and circular towers; timber and steel towers; reinforced-concrete hyperbolic towers; examples of cooling towers.

CUPOLAS

Blast Preheating. Blast Preheating in Cupolas (Theoretische Betrachtungen zur Frage der Windvorwaermung bei Kupoloefen), E. Piwowarsky and R. Vogel. Giesserei (Duesseldorf), vol. 16, no. 6, Feb. 8, 1929, pp. 147–153, 4 figs. Constants of reaction velocity for oxygen, or carbon-dioxide reactions, in range of low flow velocities are experimentally determined; results show that reactions vary and that carbon-dioxide reaction is not altogether accurate indication of combustibility of fuels; conditions at higher flow velocities are also examined.

Hot-Blast. Hot-Blast Cupola in Pullman Foundry, R. A. Fiske. Iron Age, vol. 123, no. 13, Mar. 28, 1929, pp. 872–875, 7 figs. Advantages resulting from replacement of two cold-blast cupolas by single hot-blast unit at Michigan City, Ind., plant of pullman-car and Mfg. Corp.; equipment installed includes skip hoist; results of operating test.

Performance. An Analysis of the Performance of Fifty-Four Inch Cupolas Based Upon Records of Practical Operation, E. E. Marbaker. Am. Foundrymen's Assn.—Preprint, no. 29–34, for mtg. Apr. 8–11, 1929, pp 71–90, 3 figs.

Rational procedure for cupola operation, based on comparison of actual results of practical operation of two series of 54-in. cupolas from questionnaire; effect of boshed linings on melting rate; temperature of molten iron; coke consumption; thermal efficiency; air supply; theoretical calculation of coke and air; value of second row of tuyères.

CUTTING TOOLS

Grinding. Influence of Regrinding Practice on the Efficiency of Cutting Tools, N. N. Sawin. Am. Mach., vol. 70, no. 13, Mar. 28, 1929, pp. 505–507, 4 figs. Standardized procedure in Skoda Works, Pilsen, Czechoslovakia, for grinding, cutting tools and tests from which standards were set are described; limits, based on test results, are placed on permissible loss of hardness due to heat generated in dry grinding.

CYLINDERS

Thick - Walled, Stresses in. Combined Stresses in Thick-Walled Cylinders, E. B. Norris. Am. Soc. Mech. Engrs.—Advance Paper, for mtg. Mar. 21–23, 1929, 5 pp., 7 figs. Description of tests which were made on 11 thick-walled cylinders of high-quality gun steel, ranging in bore from 3 to 9.5 in. and with ratios of outside diameters of 1.5, 2 and 3; evidence that maximum-strain theory of St. Venant is correct for cases of tension and compression in mutually perpendicular planes where tension stress is greater of two.

D

DIESEL ENGINES

Automotive. Automotive Diesel Engines Near. Soc. Automotive Engrs.—Jl., vol. 24, no. 3, Mar. 1929, pp. 259–260. Review of meeting of Southern California Section with brief abstracts of papers; principles of oil-engine operation, air-injection and mechanical-injection methods of getting fuel into cylinders, described by L. T. Pockman; Diesel airplane engine described by L. M. Griffith; European Diesels reviewed; cost compared with gasoline engine.

Light Diesel Engines for Automobile and Aircraft (Les moteurs Diesel legers pour l'automobile et l'aéronautique), G. Delanghe. Génie Civil (Paris), vol. 94, no. 12, Mar. 23, 1929, pp. 277–284, 18 figs. Recent progress in design of light Diesel engines for automobiles and aircraft is discussed; difficulties encountered in using heavy oil in ordinary internal-combustion engines; differences in construction of engines with direct mechanical injection and of those with superheated anti-chambers; equipment for injection and regulation; details of Acro and Sauer direct mechanical-injection engines; design of Peugeot-Junkers engine.

Supercharging. Diesel Engines With Buechi Exhaust - Gas Turbo - Supercharging (Dieselmotoren mit Buechi-Abgasturbinenaufladung), A. Buechi. Waerme (Berlin), vol. 52, no. 6, Feb. 9, 1929, pp. 125–128, 6 figs. Advantages of this system are set forth and compared with other Diesel-engine systems; use of exhaust-gas turbo-blowers with new and old engines.

Waste-Heat Utilization. Utilization of the Waste Heat From the Diesel Engine Plant, C. L. Hubbard. Nat. Engr., vol. 33, nos. 1 and 2, Jan. and Feb. 1929, pp. 1–4 and 57–61, 8 figs. Description of various methods for abstracting heat from exhaust of Diesel engines; economizers, or gas boilers; examples involving calculations of this character; heating water for process work; test data and results in practice. Feb.: General principles of waste-heat recovery from this type of prime mover; computing amount of heat available; extracting heat from exhaust gases; equipment required and its characteristics; regulating devices for controlling operation.

E

ELECTRIC FURNACES

Induction. The Metrovick Coreless Induction Furnace. Iron and Coal Trades Rev. (Lond.), vol. 118, no. 3184, Mar. 8, 1929, pp. 362–363, 4 figs. Notes on construction and operating costs of improved types of furnace developed by Metropolitan-Vickers Electrical Co.; steel furnaces of 500-lb. and 350-lb. capacity; furnace for brass and other non-ferrous metals is mentioned, but not specifically described; tabular data on performance and comparison of ingot analyses; operating cost, on bases of 550 tons steel per year, is about 5 pounds 7 shillings per ton.

Resistance. An Improved Form of Electric Resistance Furnace, E. Rosenhain and W. E. Prytherch. Engineering (Lond.), vol. 127, no. 3296, Mar. 15, 1929, pp. 339 and 353. Electric resistance furnace is described for which advantages are claimed in regard to higher available working temperatures (up to 1400 deg. cent.), durability, and freedom from oxidation of carbon resistor; heating element consists of carbon or graphite pellets, or short rods placed end to end in refractory sheating tube which fits easily over them; heating occurs by contact resistance.

Electric Resistance Furnaces in the Workshop (Elektrische Widerstandoefen im Werkstaettenbetriebe), H. Tamele. Siemens-Zeit. (Berlin), vol. 9, no. 2, Feb. 1929, pp. 101–108, 2 figs. Use of chrome-nickel heating elements in furnaces up to 1000 deg. cent.; ceramic lining; muffle furnaces; hardening and melting furnaces of Siemens and Schuckert and their application.

ELECTRIC WELDING

Arc. Metal Arc Welding, H. Dustin. Welding Jl. (Lond.), vol. 26, nos. 304 and 305, Jan. and Feb., 1929, pp. 17–18, 20, 48–50 and 52. Jan.: Effect of weld on base metal; comparative tests; mechanical properties of weld covering modulus of elasticity, maximum tensile strength and appearance of fracture. Feb.: Properties of elastic limit, elongation, work of rupture, shearing strength, impact, ductility, and fatigue of welds are discussed; special note on shearing. From Revue Universelle Des Mines (Liège), translated by F. T. Llewellyn for Am. Welding Soc.—Jl.

Electric Machinery. Welded Steel Construction for Electric Machinery and Transformers (Geschweisste Stahlkonstruktionen im Elektromaschinen- und Transformatorenbau), E. Lasswitz. Bergmann Mitteilungen (Berlin), vol. 6, no. 12, Dec. 1928, pp. 310–318, 23 figs. In modern manufacturing cast parts are replaced by welded-steel construction; electric welding of generator frame and transformer cases, machine bass, hood covers, and radiation cover for large transformers, various small machine parts, etc.

ELEVATORS

Electric, Control of. Automatic Elevator Control, L. J. Kinnard. Elec. Jl., vol. 26, no. 3, Mar. 1929, pp. 131–133, 3 figs. Single and two-button multi-call; schedule multi-call; typical installation of multi-call control of three cars; two-button multi-call selector; two-button multi-call controller; conditions suitable for automatic elevators.

Elevators Automatically Controlled by Pliotron Tubes, W. O. Lum. Power, vol. 69, no. 13, Mar. 26, 1929, pp. 507–508, 4 figs. Use of pliotrons to level car automatically with landings; pliotron composed of filament, grid and plate will oscillate if coils are arranged in grid and plate circuits in proximity to each other and if grid coil is suitably tuned with capacitor across it; frequency at which circuit oscillates is determined by frequency of tuned grid circuit; General Electric elevator-leveling unit is about 200 kilocycles.

F

FLOORS

Concrete, Wear Tests of. Wear Tests of Concrete Floor Finishes for Industrial Buildings, J. G. Ahlers, J. J. Linden, and M. F. Bird. Eng. and Contracting, vol. 68, no. 4, Apr. 1929, pp. 176–178, 2 figs. Nine types tested at Macy warehouse; schedule of finishes; depth of worn grooves in various panels and unit costs per square foot; proportions of strength of mixtures in different floor panels. Paper presented before Am. Concrete Inst.

FLOW OF GASES

Nozzle Discharge Coefficients. Discharge Coefficients of Standard Nozzles and Orifices for Pipe Diameters of 100 mm. to 1000 mm. (Die Durchflusszahlen von Normalduesen und Normalstauraendern fuer Rohrdurchmesser von 100 bis 1000 mm.), M. Jakob and F. Kretzschmer. Forschungsarbeiten auf dem Gebiete des Ingenieurwesens (Berlin), no. 311, 35 pp., 98 figs. Report from German Government Institute of Engineering Physics on tests of flow of air in volumes up to 10,000 cu. m. per hr. through 10 types of standard nozzles and 38 types of standard orifices; effect of Reynolds coefficient; recovery of pressure; tests were made at Roechling steel works at Voelklingen. Bibliography.

FLOW OF STEAM

Orifices. Measuring Steam Flow by Means of Calibrated Orifices, Particularly With Diaphragms (La mesure des debits de vapeur à l'aide d'orifices calibrés), L. Koehler. Assns. Francaises de Propriétaires d'Appareils à Vapeur—Bul. (Paris), vol. 9, no. 34, Oct. 1928, pp. 313–324, 4 figs. Method based on measuring steam pressure, velocity, etc., at passage through apertures in partitions placed in steam pipe line.

FORGING MACHINES

Horizontal. Horizontal Forging Machines (Wagerecht-Schmiedemaschinen), H. Fey. Stahl u. Eisen (Duesseldorf), vol. 49, no. 10, Mar. 7, 1929, pp. 315–324, 27 figs. Field of application of forging machines and their advantages in production of forged parts; general description of forging process; details of different makes of machines.

FORGINGS

Cleaning. Cleaning Forgings in Shortened Time. Iron Age, vol. 123, no. 11, Mar. 14, 1929, p. 742, 1 fig. Continuous process of cleaning forgings adopted at Cleveland Hardware Co., Cleveland, is described; pickling and tumbling combined in one barrel, followed by soda cleansing in second; operation facilitated by loading skip.

FURNACES, INDUSTRIAL

Research. Fundamental Studies of Furnace Design. Iron Age, vol. 123, no. 12, Mar. 21, 1929, pp. 807–808, 2 figs. Description of industrial-furnace department conducted separately from production department which is maintained by Surface Combustion Co., Toledo, Ohio, to solve problems in making industrial furnaces keep pace with progress of other mechanical equipment; development laboratory uses basic data in approaching particular problems for many industries; working with purchaser; survey of process industries; experimental model followed by full-size furnace.

FURNACES, MELTING

Gas - Fired. An Open - Flame Stationary Hearth-Type Furnace for Melting Aluminum and Its Alloys, R. J. Anderson, G. E. Hughes and M. B. Anderson. Am. Foundrymen's Assn.—Preprint, no. 29-36, pp. 153–162, 3 figs. Consideration of melting furnaces in general; description of 12,000-lb. capacity gas-fired furnace; cross firing is employed; application in melting different materials; fuel efficiency and cost of melting.

FURNACES, METALLURGICAL

Pulverized-Coal. Furnace Heating by Means of Pulverized Fuel, G. E. K. Blythe. Metal Industry (Lond.), vol. 34, nos. 7 and 9, Feb. 15 and Mar. 1, 1929, pp. 177–179 and 231–232. See also Foundry Trade Jl. (Lond.), vol. 40, no. 653, Feb. 21, 1929, pp. 147–148 and 150. Feb. 15: Consideration of fuel economy side of metallurgical heating; relative suitability of solid, liquid, and gaseous fuels; coal firing has been neglected; highest attainable temperature for heating is obtained with pulverized fuel because of small amount of excess air required; details of ring roller mill; regulating degree of fineness. Mar. 1: Forge reheating furnaces. Read before Inst. of Metals.

G

GEAR-CUTTING MACHINES

Automatic. Automatic Gear-Tooth Rounding Machine. Engineering (Lond.), vol. 127, no. 3295, Mar. 8, 1929, p. 315, 6 figs. on p. 314. Machine for automatically rounding ends of teeth of chrome-steel sliding gears used in all-geared headstocks of machine tools; capable of rounding teeth of from 3 to 12 diametral pitch on wheels ranging from $2^1/_2$-in. to 26 in. in diam., and teeth up to 6 diametral pitch can be rounded at rate of 20 per minute.

GRINDING

Choice of Wheels. Proper Choice of Wheels Reduces Grinding Costs on Large Steel Parts, F. B. Jacobs. Abrasive Industry, vol. 10, no. 1, Jan. 1929, pp. 1–4, 8 figs. Description of number of interesting grinding operations on manganese steel at plant of Marion Steam Shovel Co., Marion, Ohio; few grinding operations on carbon steel wherein grinding has been found to be more economical than turning in finishing comparatively large units.

H

HARDNESS TESTING

Conversion of Hardness Numbers. Conversion of Hardness Numbers, A. Heller. Am. Mach., vol. 70, nos. 14 and 15, Apr. 4 and 11, 1929, pp. 535–539 and 583–586, 10 figs. Apr. 4: Discussion of why single Brinell-Rockwell conversion table cannot be used for all steels; present tables for converting from Brinell to Rockwell, although reasonably accurate for B scale, differ by as much as ten numbers on C scale. Apr. 11: Discussion of how influence of indenter shape on cold working of different steels leads to errors when using common conversion tables.

HEAT CONDUCTIVITY

Problems in. A Survey of Heat Conduction Problems, E. Griffiths. Engineering (Lond.), vol. 127, no. 3293, Feb. 22, 1929, p. 251. Several forms of thermal-conductivity apparatus are described which had been devised for study of diverse materials ranging from sheet of mica to wall section weighing half ton. Abstract of paper and discussion presented before Phys. Soc.

HEAT TRANSMISSION

High-Temperature. Transmission of High Temperatures, A. L. Walker. Power Eng. (Lond.), vol. 24, no. 276, Mar. 1929, p. 86. Notes on media for process heating; it is fairly simple matter to transmit heat at high temperatures so long as no danger would result by overheating; method of using superheated steam which is not employed extensively is that of passing steam direct into fluid required to be heated; oil heating; use of alloy steels for coils, particularly nickel-chromium steels.

HOISTS

Chain, Tests on. Speed of Hoisting with Chain Hoists. Am. Machy., vol. 70, no. 13, Mar. 28, 1929, p. 525, 3 figs. Results of tests involving 11 operators, 23,550 ft. of hand chain operation, 153 min. pulling time, and 1,268,000 ft.-lb. of work; data furnished by Harrington Company.

HYDRAULIC TURBINES

High-Head. Francis Turbines for High Heads, F. J. Taylor. Mech. World (Manchester), vol. 85, no. 2200, Mar. 1, 1929, pp. 191–194, 5 figs. Discussion of conditions which normally govern final choice of turbine and description of some recent installations; adaptability of vertical-shaft turbine to high heads; design and construction of Pelton Wheel Co., Allis-Chalmers, and Escher-Wyss turbines; horizontal turbines.

Testing. British Standard Specification for the Testing of Hydraulic Turbines. Brit. Eng. Standards Assn. (Lond.), vol. 353, Mar. 1929, 12 pp. Specifications cover definitions, conditions and methods of tests, information required with order, and units and notations.

HYDROELECTRIC POWER PLANTS

Needle Valves. Automatic Self - Closing Needle Valves. Water and Water Eng. (Lond.), vol. 31, no. 363, Mar. 20, 1929, pp. 129–130, 1 fig. Details of 21-in. to 11-in. diam. patent, automatic, self-closing needle valve, with precision timing gear designed and constructed by Glenfield and Kennedy, Ltd., for Hermitage Dam hydroelectric scheme in Jamaica.

Pumped-Storage. The Hydraulic Storage of Power, R. W. Mueller. Power Engr. (Lond.), vol. 24, no. 276, Mar. 1929, pp. 108–110, 5 figs. With water accumulation means is available for storing energy which is to hand but is not required at moment for power generation; this is achieved by driving pumps to raise water into high-level basis from which water is drawn in times of need for driving water turbines; load equalization; details of some actual accumulation plants.

I

ICE PLANTS

Operation. Practical Plant Operation, W. E. Bernd. Refrig. World, vol. 64, no. 3, Mar. 1929, pp. 32–33 and 36–37. Consideration of weak brine, poor agitation, insufficient charge of ammonia, duty ammonia, poor distribution of liquid in coils, irregular expansion or admission of liquid to coils, harvesting of ice, filling cans with warm water, solid ice allowed to rewarm in tanks, and sending warm liquid into coils. Read before Nat. Assn. Practical Refrig. Engrs.

IMPACT TESTING

Notched—Bar. Notch Strength and Static Characteristics (Kerbzaehigkeit und statische Kennziffern), W. Kuntze. Archiv fuer das Eisenhuettenwesen (Duesseldorf), vol. 2, no. 9, Mar. 1929, pp. 583–589 and (discussion) 590–593, 9 figs. Influence of velocity of deformation on curve of true stresses; relation between notch resistance and strength and deformation properties of materials of same chemical composition; tests with different materials; influence of preliminary stretching on rupturing and notch resistance; material sensitives to blows.

INDUSTRIAL MANAGEMENT

Ability Testing. Recent Developments in Industrial Psychology (Die neuere Entwicklung der psychotechnischen Begutachtung), E. Oberhoff. Archiv. fuer das Eisenhuettenwesen (Duesseldorf), vol. 2, no. 9, Mar. 1929, pp. 601–606, 6 figs. Notes on mass and individual evaluation of psychological adaptability tests; description of present method of adaptability testing, based on individual analysis; according to new methods each individual case is given longer, more thorough test in which vocational ability of candidate is disclosed.

Executives, Training of. Training Executives in the Habit of Thought and Industry, W. N. Polakov. Soc. Indus. Engrs.—Bul., vol. 11, no. 2, Feb. 1929, pp. 15–17. Younger executive in any organization should be trained to study and analyze such graphic charts as progress chart, idleness chart, man record chart, and layout charts; graphic analysis and control of production by means of Gantt charts, sets tasks before management and offers record of administrative efficiency.

Maintenance Control—Records. Records Are Vital in Service to Production. Indus. Eng., vol. 87, no. 3, Mar. 1929, pp. 110–114, 5 figs. Representative record forms actually in use in industries, all aid in controlling maintenances and replacements.

Marketing. Marketing Problems of 1929, R. H. Dick. Taylor Soc.—Bul., vol. 14, no. 1, Feb. 1929, pp. 29–34 and (discussion) 34–38. Sound sales policies and organization are made up to proper knowledge of markets; proper sales promotion plans; proper sales strategy and campaigns, with ways and means of making them effective; proper publicity, both in advertising and propaganda work; proper operating costs, controlled by budget; proper control by systems and statistics; proper handling of personnel, including selection, allotment of tasks, compensation, training, inspiration and supervision; and proper understanding of and cooperation with aims and activities of general management.

Metal-Working Plants. Managerial Ideas from Labor Pay Metalworking Plant, E. C. Barringer. Iron Trade Rev., vol. 84, no. 11, Mar. 14, 1929, pp. 701–704, 6 figs. Description of system developed in plant of Foster Bolt and Nut Co., Cleveland, under which foremen and older employees formed three committees dealing with quality, service, and cleanliness and sanitation; needing more management to meet new competition, company developed it in ranks; shop committees raised quality, lowered costs; conditions arising during week discussed at committee and progress reports made.

Small Plants. Management Engineering in the Smaller Industrial Plants, J. E. Dykstra. Can. Machy. (Toronto), vol. 40, no. 6, Mar. 21, 1929, pp. 48–50. Problems of production control, grouping, and classification of equipment, time study, man power, possibilities of modern equipment, and importance of operating personnel are discussed. Paper presented before Am. Soc. Mech. Engrs.

Time Study. The Relation of Time-Study to Production, L. W. Haskell. Soc. Automotive Engrs. Jl., vol. 24, no. 3, Mar. 1929, pp. 273–274 and (discussion) 274–277. See also Abrasive Industry, vol. 10, no. 3, March 1929, p. 112. Practical application of time study to industry; time study reduces idle time of men and machinery, prevents purchase of unnecessary new equipment, provides accounting department with accurate labor cost per unit of production, assures higher quality of product and improves labor conditions.

INDUSTRIAL PLANTS

Germany. The Works and Products of the Demag Aktiengesellschaft. Ry. Engr. (Lond.), vol. 50, no. 590, Mar. 1929, pp. 98–103, 6 figs. Plant is described which specializes in mine and quarry equipment, blast-furnace plants, steelworks equipment, rolling-mill equipment, shipbuilding plants, harbor installations, foundry and workshop equipment, structural steel, gearing, etc.

Location. Select Plant Sites to Fit All Your Needs, J. A. Piquet. Factory and Indus. Mgmt., vol. 77, no. 3, Mar. 1929, pp. 491–493, 2 figs. Large number of plants, that are relocating warrants inquiry into reasons for geographical changes chief among which are a necessity for getting near to important growing markets, need for better space, transportation facilities, and labor conditions.

INDUSTRIAL TRUCKS

Electric, Operation Costs of. Using Electric Industrial Trucks to Reduce Production Costs, C. B. Crockett. Iron Trade Rev., vol. 84, no. 13, Mar. 28, 1929, pp. 849–851 and 860, 6 figs. Analysis of materials handling equipment owned by 105 plants in metal working industry is discussed; average yearly costs for approximately 100 plants; operating costs vary widely with plant conditions; use of trucks in Ames Mfg. Co., Jersey City, N. J.; savings effected in Jones and Laughlin Steel Corp., Pittsburgh.

INDUSTRIES

Advantages Offered by South. What the South Offers Industry, R. S. Henninger. Factory and Indus. Mgmt., vol. 67, no. 4, Apr. 1929, pp. 715–717, 8 figs. Discussion of industrial developments of South and probable effect upon developments in other sections of country; advantages South offers industries, are, water power, cheap labor, 58 per cent of world's cotton, 48 per cent of country's lumber, one-third of country's coal and ever widening transportation facilities.

INTERNAL-COMBUSTION ENGINES

[See AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; MOTOR-TRUCK ENGINES; OIL ENGINES.]

INTERNAL-COMBUSTION TURBINES

Possibilities of. Internal-Combustion Turbine (La turbine à combustion interne), M. Roy. Chaleur et Industrie (Paris), vol. 10, no. 105, Jan. 1929, pp. 11–16. Possibilities of realization and of future application in aviation are discussed.

IRON CASTINGS

Acid-Resisting. Acid-Resistant Cast Iron, F. Espenhahn. Foundry Trade Jl. (Lond.), vol. 40, no. 655, Mar. 7, 1929, p. 186. Results of scientific investigations of iron-silicon and iron-silicon-carbon diagram and its bearing on ideal composition of commercial alloys; discussion of chemical and physical properties of silicon iron; comparison of different methods of producing acid-resisting silicon alloys. Abstract translated from Giesserei, Sept. 14, 1928.

Chilled. Influence of Temperature of Molten Metal on Chill Castings (Ueber den Einfluss der Giesstemperatur beim Hartguss), F. Busse. Giesserei (Duesseldorf), vol. 16, no. 8, Feb. 22, 1929, pp. 169–179, 23 figs. Results of research and author's own experience on influence of temperature of molten metal on depth of hardness, transition from white to gray zone, occurrence of cracks and blowholes, etc.; microscopic analysis; relations between temperature of molten metal and crystallization; conclusions applied to foundry practice. Bibliography.

Cleaning. New Process of Cleaning and Refining Castings (Un Nouveau Procédé de Decrassage et d'Affinage de la Fonte des cubilots), H. Knorth. Fonderie Moderne (Paris), vol. 23, Jan. 25, 1929, pp. 31–32, 1 fig. Details of new method and device developed by Freier Grunder Eisen und Metallwerke, Neunkirchen, Westphalia, for removing impurities of metal in molten state.

Foundry Practice. Some Factors in the Production of Sound Gray Iron Castings, R. W. Kurtz and K. S. Clow. Am. Foundrymen's Assn.—Preprint, for mtg. Apr. 8 to 11, 1929, pp. 163–182, 8 figs. Designing to simplify foundry practice as much as possible is important; molding materials should be tested and control methods arranged especially for moisture in green sand molds; pouring should be at proper temperatures and in such manner that iron-oxide particles may not become entrained in casting; combination permeability; tensile tests; blowability tests.

IRON FOUNDRIES

Materials Handling in. Materials Handling in Gray Iron Foundries, A. Walton. Am. Foundrymen's Assn.—Preprint for mtg. Apr. 8–11, 1929, pp. 235–258. Description of various materials-handling operations; factors to be studied in installation of labor-saving equipment; some applications of lifting magnets; portable crane with single-line bucket; tractor trucks; cupola charging; unloading material; distribution of molten metal; conveyor table mechanism; handling large tonnage of small castings; unusual plans for reducing costs; dust collection and handling.

L

LOCOMOTIVES

Axle Bearings. The Heating of Locomotive Axle Bearings, H. B. Buckle. Int. Ry. Congress Assn.—Bul. (Brussels), vol. 11, no. 2, Feb. 1929, pp. 195–204, 6 figs. Practical notes of interest to locomotive running and maintenance staffs on causes and methods of avoiding hot boxes; design of bearing; method of applying lubricant; operations for lifting engines for hot driving axle box with electric sheer legs; cost of lifting, etc., of engine for heating bearing; question of supplying higher-grade oil; connecting-rod big-end journals. From Ry. Engr., Oct. 1928.

Boilers, High-Pressure. High Pressure Water Tube Boilers, L. A. Rehfuss. Boiler Maker, vol. 29, no. 3, Mar. 1929, pp. 76–79, 3 figs. Details of proposed high-pressure locomotive boiler incorporating circulation, by which all water must pass successively up and down through series of cross-drum tube sections before reaching firebox zone.

Canadian Pacific. Two 4-8-4 Type Locomotives Built by Canadian Pacific. Ry. Mech. Engr., vol. 103, no. 3, Mar. 1929, pp. 122–126, 8 figs. Unusual design used on shut-off valve, drawbar and arch-tube sleeves; alloy steel used extensively throughout.

Diesel-Electric. Diesel-Electric Passenger Locomotive for New York Central, S. T. Dodd. Ry. Age, vol. 86, no. 12, Mar. 23, 1929, pp. 663–667, 8 figs. Details of 12-cylinder, air-injection engine developing 900 hp. and having governed-torque, multiple-unit control; four compartments in cab; main generator is of multi-polar type carrying 10 main poles and 10 commutating poles.

Feedwater Preheaters. Exhaust-Steam Feedwater Preheater and Injector (Abdampfvorwaermer und Abdampfinjektor), Juliusburger. Glasers Annalen (Berlin), vol. 104, nos. 3 and 4, Feb. 1 and 15, 1929, pp. 40–48 and 53–60, 24 figs. Based on article of Corbellinus' experiments of Italian states railroads with exhaust-steam preheaters for locomotives in Revista Technica delle Ferrovie Italiana, author concludes from mathematical and experimental derivations that exhaust-steam injector lags in competition with exhaust-steam preheater and plunger pump, in operation as well as from thermal-economic standpoint.

Geared. Geared Steam Locomotives for Industrial Services. Modern Transport (Lond.), vol. 20, no. 520, Mar. 2, 1929, p. 11, 3 figs. Description of two geared steam locomotives, one of 0-6-0 and other of 0-4-0 wheel arrangement supplied by Atkinson Walker Wagons, for new works of Oxford and Shipton Cement, Ltd.; high-pressure Uniflow engines.

Pulverized-Coal-Fired. The Use of Pulverized Fuel on the German State Railways, Landsberg. Engineering (Lond.), vol. 127, no. 3293, Feb. 22, 1929, pp. 219–222, 6 figs. Details of Henschel locomotive on which tests are being conducted under supervision of German State Railways; pulverized-fuel supply is carried in self-clearing hopper on tender, and is transported by two screw conveyors to burner feed pipes; feeding is effected by primary air, which enters firebox through burners in intimate contact with fuel.

LUBRICANTS

Cutting. Cutting and Quenching Oils, C. H. Hudson. Junior Instn. of Engrs.—Jl. (Lond.), vol. 39, no. 5, Feb. 1929, pp. 215–223. Study of cutting oils and their influence on production; lubricate ship-over and along-lip of tool and so lengthen life of tool; disperse as rapidly as possible heat set up by tool-removing stock; to wash away chips, keep work clean; no tendency to rust finished work or machines; to remain sweet and not turn rancid for reasonable time; to be antiseptic, so that operators are not on sick list through sores and skin troubles caused by oil setting up irritation when getting into cuts, scratches, etc.

LUBRICATING OILS

Voltol Process. Voltol (Voltol), K. Wolf. Petroleum (Berlin), vol. 25, no. 3, Jan. 16, 1929, pp. 95–98. Lubricating oils, according to Voltol process, are produced by subjecting mineral oils, tar, fatty oils, or mixtures of mineral and fatty oils to glowing electrical discharge, alternating current at 5000 volts being employed; process is carried out at about 80 deg. and in vacuum of 60–70 mm., using aluminum electrodes.

LUBRICATION

Spreading of Lubricants. Friction and Spreading of Lubricants (Schmiermittelreibung und Stroemmuugsorientierung), S. Kyropulos. Zeit. fuer Technische Physik (Leipzig), vol. 10, no. 2, 1929, pp. 46–52, 2 figs. Hydrodynamic theory and modifications; viscosity, density and molecular structure of layers; castor-oil additions; viscosity and support of journals; measurements on lubricating grooves.

M

MACHINE PARTS

Fillet Stresses. Shear Stress in Certain Thin Fillets, P. Gillespie, C. A. Hughes, K. B. Jackson and J. H. Fox. Univ. of Toronto, School of Eng. Research—Bul. (Toronto), no. 8, sec. no. 3, 1928, pp. 73–78, 4 figs. Details of experiment whereby, by means of short-length Martens extensometers, effort was made to determine stress in tension member secured to two other tension members, one on either side of it, by thin web-like fillets; these fillets were not weld fillets but were made by milling superfluous metal out of 3 in. x 1 in. bar of mild steel.

Standardization. Standardization of Small Machine Parts, T. Addison. Am. Mach., vol. 70, no. 11, Mar. 14, 1929, p. 435. Possibilities of reducing costs by standardization of small parts are discussed; other companies can frequently produce and sell details cheaper and just as accurate as they can be made in home plant; drop forgings, standard stampings, bushings, and locknuts available.

MACHINE SHOPS

Dust Elimination. Dust in the Workshop (Der Staub in der Werkstatt), H. Roegnitz. Werkstattstechnik (Berlin), vol. 23, no. 1, Jan. 1, 1929, pp. 65–69, 11 figs. Accumulation of dust, in foundries, steel grinding mills, machine shops, etc.; its effect on machinery and means of prevention, are discussed.

England. Largest Machine Tool Machine Shop in World at Coventry. Can. Machy. (Toronto), vol. 40, no. 4, Feb. 21, 1929, pp. 37–41, 11 figs. Description of huge Alfred Herbert plant in England is given; machine shop covers 7 acres; foundry facilities; plant heating and ventilating; routing work through shops; works and factory each self contained; drilling and boring; grinding and testing departments described.

MACHINE TOOLS

Design. Changes in Machine Tool Design, E. G. Gilson and G. N. Sieger. Iron Age, vol. 123, no. 14, Apr. 4, 1929, pp. 948–949. Possibilities of changes in machine-tool design to permit their highest productiveness with high-speed cemented tungsten-carbide cutting tools; tailstock center problem; coolants will be used, as now; efforts concentrated on lathe tools. Abstract of paper presented before Am. Soc. of Mech. Engrs. and West. Soc. of Engrs.

Present-Day Developments in Machine Tools, E. W. Tipple. Machy. Market (Lond.), nos. 1477 and 1478, Feb. 22, and Mar. 1, 1929, pp. 161–162 and 183–184. Feb. 22: Developments in machine-tool design are discussed; cutting speeds and feeds; multiple tooling; setting times; non-cutting times; lubrication; machine drives; Hele-Shaw and Williams-Janney types of variable-speed gear; broaching-machine drives. Mar. 1: Trend in machine details; four methods of hydraulic feed and reasons for adoption of different systems on different types of machines. Paper read before Inst. Engrs. and Shipbldrs.

Electric Control. Advantages of Push-Button Control of Machine Tools (Vorteile der Druckknopfsteuerung an Werkzeugmaschinen), J. Bleck. Werkzeugmaschine (Berlin), vol. 33, no. 3, Feb. 15, 1929, pp. 41–44, 8 figs. Economy attained by increased output and quality of work, simplified design and protection against overload and wrong handling of machines.

Lubrication. Centralized System Used to Lubricate Tools at Chrysler. Automotive Industries, vol. 60, no. 13, Mar. 30, 1929, p. 509, 3 figs. Details of central combination pressure and wick feed system in Highland Park plant of Chrysler Motor Co. for automatically lubricating 322 bearing surfaces on 50 double-ended buffing machines; system is product of Stanley Automotive Products, Inc.; compensation for changes in viscosity with temperature.

MATERIALS HANDLING

Automobile Plants. See AUTOMOBILE PLANTS.

Iron Foundries. See IRON FOUNDRIES.

Sheet Metal. Sheet Handler Aids in Loading and Unloading Sheets. Can. Machy. (Toronto), vol. 40, no. 5, Mar. 7, 1929, pp. 64 and 66, 3 figs. Improved methods of handling metal sheets are discussed; elevating truck system; details of truck which will place 10-ton package of steel in corner of box car, handling packages up to maximum of 48 by 102 in. through door 6 ft. wide; sheet handler will load 2000 tons of sheet in 10-hr. day.

The Baker Sheet Handler. Iron and Coal Trades Rev. (Lond.), vol. 118, no. 3185, Mar. 15, 1929, pp. 398–399, 3 figs. Brief discussion of unsatisfactory and troublesome methods of handling steel sheets in shipments; description of Baker sheet handler, developed by Baker-Raulang Co. of Cleveland, Ohio, will load about 2000 tons of sheets in 10-hr. day with 1 operator and 1 helper; 2 men can load about 80 tons per day by hand.

METALS

Cold Working. Strength and Angle of Shear of Cold-Rolled Metals (Ueber die Festigkeitseigenschaften und den Reisswinkel kaltgewalzter Metalle), F. Koerber and H. Hoff. Mitteilungen aus dem Kaiser-Wilhelm-Institut fuer Eisenforschung zu Duesseldorf (Duesseldorf), vol. 10, no. 9, 1929, pp. 175–187, 32 figs. Results of tests to determine strength, tensile strength, elongation and Brinell hardness of cold-worked copper, aluminum, brass, electrolytic iron, and nickel.

Gas Determination in. Gases in Metals. Metallurgist (Supp. to Engineer, Lond.), Feb. 1929, pp. 17–18. During recent years, increasing attention has been given to question of gases in metals, mainly from two points of view: one relates to analytical determination of gas content in given sample, while others relate to problem of eliminating gas from metal; while important work that is being done on removal of gases should be followed with interest, it is wise to inquire whether there are not circumstances in which certain gases may play useful or even necessary part.

Machinability. Machinability, Drilling, and Twist Drills (Bearbeitbarkeit, Bohrarbeit und Spiralbohrer), S. Patkay. Werkstattstechnik (Berlin), vol. 23, nos. 1 and 2, Jan. 1 and 15, 1929, pp. 3–10 and 33–42, 34 figs. Jan. 1: Arrangement and results of drilling tests; photographs of steel alloys tested with twist drills; blunting curves of drills showing depth of drilling until dullness as function of speed; feed curves and blunting curves as characteristics of machinability of work materials. Jan. 15: Forces acting on twist drills and general considerations regarding machinability.

Testing. Electrical Resistance Measurement Determines Endurance of Metals, K. Honda. Automotive Industries, vol. 60, no. 12, Mar. 23, 1929, pp. 476–478, 3 figs. Method for accurately noting point at which elasticity ends is described; time saving is feature; method originated by Shoji Ikeda of Japanese Government Railways Research Department; tests and endurance machine are described. Abstract of paper presented before Am. Soc. Steel Treating.

The Deformation of Metals, with Special Reference to the Tensile Test, C. H. Desch. Iron and Coal Trades Rev. (Lond.), vol. 118, nos. 3184 and 3185, Mar 8 and 15, 1929, pp. 361 and 391. Mar. 8: Elastic, plastic and viscous deformation; tensile test determines proportionality and elastic limits, proof stress, yield point, maximum load, elongation, and reduction of area. Mar. 15: Steel hardening in tension; failure by shear; reduction as indication of ductility; compression test; capacity for cold working; viscous flow. Read before Inst. of Engrs. and Shipbldrs. of Scotland.

Vacuum Melting. Vacuum Melting, W. Rohn. Metallurgist (Supp. to Engineer, Lond.), Feb. 22, 1929, pp. 26–27. Facts and figures in regard to production of vacuum-melted metals in 1919–1928; important feature of vacuum process described is fact that casting into water-cooled copper ingot molds is also done under high vacuum; among materials produced by these methods, special alloys for use as thermocouples, both base metal and platinum, are important. Abstract translated from Zeit. fuer Metallkunde, Jan. 1929.

MOTOR BUSES

Design, European. Recent European Bus Design Follows Radical Lines. Bus Transportation, vol. 8, no. 3, Mar. 1929, pp. 136–139, 10 figs. Some of more important engineering features of recent European development are covered; front-wheel drive; offset rear axles; novel points of Aboag front-wheel-driven vehicle of German design; new 6-cylinder Diesel successfully tried in England; unusual features of Lancia Omicron bus chassis produced in Italy.

MOTOR-TRUCK ENGINES

Governors. Governors—Fundamentals of Design and Application, G. L. Moyers. Power Wagon, vol. 42, no. 291, Mar. 1929, pp. 16–18 and 20, 5 figs. Speed control of motor truck

engines is discussed; characteristics of centrifugal type of governor; details of Monarch, K. P., and Handy automatic governors.

N

NITRIDATION

Automobile Parts. Nitrogen Hardening. Automobile Engr. (Lond.), vol. 19, no. 252, Mar. 1929, pp. 91–92, 1 fig. Potentialities of nitridation process for automobile parts is discussed; for parts subjected to severe wear with possibility of defective lubrication, nitralloy steel is particularly suitable; method of operation; outstanding characteristic of nitralloy steels is inclusion of 1 per cent of aluminum; physical properties; for crankshafts, moderately hard grade of nitralloy steel recommended; elimination of anti-friction liners in these crankshafts; durability of case.

O

OIL ENGINES

Fuel Injection. New Fuel Injection Method for Oil Engines Designed, M. F. Rochefort. Automotive Industries, vol. 60, no. 12, Mar. 23, 1929, p. 475. New method of fuel injection for oil engines designed to render them more flexible described; combined mechanical and pneumatic injection method, with entirely new system of atomization, utilizing for injection, instead of pure air, gas already carbureted to proper degree and furnished by engine itself.

Great Britain. Features of Recent British Oil Engines, F. Johnstone-Taylor. Power Plant Eng., vol. 33, no. 6, Mar. 15, 1929, pp. 350–353, 6 figs. Shockless seating of valves and elimination of expansion stresses characterize recent British designs; tendency toward higher speeds; breech construction provides excellent cooling; bending stresses eliminated by cylinder construction; high velocity of cooling water.

OPEN-HEARTH FURNACES

Practice, German. Modern Open-Hearth Practice in Germany, F. Stein. Blast Furnace and Steel Plant, vol. 17, no. 3, Mar. 1929, pp. 409–414, 3 figs. Important features in furnace design, application of fuels, and proportioning of charge developed to meet present conditions are outlined; Talbot and Hoesch and Moll furnaces; Kuehn chambers; new types of steel for special requirements; silicon structural steel.

P

PICKLING

Practice and Theory. Pickling Practice and Theory, W. H. Shipman. Am. Mach., vol. 70, nos. 12 and 13, Mar. 21 and 28, 1929, pp. 457–459 and 519–520, 4 figs. Mar. 21: Results of survey of best practice pointing out need of modernization of pickling operation; hydroelectric acid for sand removal; properties of inhibitors and applications. Mar. 28: Temperature and strength of pickling baths can be measured and controlled just as are similar quantities in other departments of shop; discussion of how to test bath and how scale is removed.

POWER TRANSMISSION

Industrial. Power Transmission Layout for Industrial Plants, K. W. Knorr. Power Transmission, vol. 34, no. 3, Mar. 1929, pp. 52–90 and 17 pp. between 92 and 124, 61 figs. Methods and means for eliminating waste and increasing efficiency in distribution of power; methods of group driving; laying out belt drives; effects of high speeds; influence of pulley diameter; effective belt tension; strain in shafting; spacing bearings; proper shaft size; influence of side pull; figuring horsepower; journals, losses, idlers, and snubbing pulleys; V-belt, rope chain, and gear drives; friction drives; installation of shafts; clutches.

PUMPS

Feedwater. The Coffin High Speed Boiler Feed Pump, T. A. Solberg. Am. Soc. Naval Engrs.—Jl., vol. 41, no. 1, Feb. 1929, pp. 18–29, 6 figs. Description of turbine-driven centrifugal single-stage boiler feed pump originally developed for use on locomotives; pump is designed for 250 lb. per sq. in. delivery pressure at capacity of 155 g.p.m., when operating on steam pressure of 200 lb. per sq. in., at atmospheric exhaust pressure; rated speed is 6800 r.p.m.; installation of pump on locomotive and advantages.

Gear. The Gear Pump, H. E. Merritt. Engineer (Lond.), vol. 147, no. 3814, Feb. 15, 1929, pp. 176–178, 10 figs. Gear pump is positive in action, gives continuous discharge, and having no reciprocating parts, can be operated at high rate of speed; action of gear pump; methods of avoiding trapping; design of involute rotors; effect of pressure angle; special methods of tooth design; Roloid pump rotor tooth.

PUMPS, CENTRIFUGAL

Turbine. Turbine Pumps for High-Pressure Power Plant (Kreiselpumpensaetze fuer ein Hoechstdruck-Kraftwerk), H. Kissinger. V.D.I. Zeit. (Berlin), vol. 73, no. 12, Mar. 23, 1929, pp. 393–396, 10 figs. Diagram of high-pressure power house with special reference to pump installation; high temperature and supply pressure demand special consideration of feedwater pumping equipment; advantages in combining auxiliary pumps of condenser installation.

R

RAILWAY MOTOR CARS

Justification of Adoption. Rail Motor Car Section. Ry. Age (Motor Transport Sec.), vol. 86, no. 12, Mar. 23, 1929, pp. 705–706. Review of Rail Motor Car Section meeting of Motor Transport Division of American Railway Association with brief abstracts of papers and reports of committee; Reliable Formula on Which to Base Decision as to Whether Purchase of Self-Propelled Equipment to Replace Steam Train Is Justified, J. K. McNeillie.

Gasoline, Argentina. Rail Motor Coach for the Argentine. Modern Transport (Lond.), vol. 20, no. 521, Mar. 9, 1929, pp. 27 and 34, 4 figs. Details of double-truck inspection coach equipped with internal-combustion engine recently built by Drewry Car Co. for Buenos Aires Great Southern Railway; engine using gasoline as fuel has six cylinders of $5^1/_2$- by $6^1/_2$-in. bore and stroke; 95 to 100 hp. developed at 1000 r.p.m.; three speeds.

ROLLING MILLS

Electrification. Electrification of Rail Steel Rerolling Mill, A. J. Whitcomb. Blast Furnace and Steel Plant, vol. 17, no. 3, Mar. 1929, pp. 415–417 and 435, 9 figs. Reduction of operating costs ensued when steam drives were replaced by motors at Pollak Steel Co., Marion, Ohio; two Kramer sets of 1200 and 800-hp. capacity, respectively were purchased; new 600-hp. pedestal type, wound rotor induction motor, rated at 707 r.p.m. for 16-in. roughing-mill drive; new equipment includes two synchronous motor-generator sets of 200-kw. capacity to supply 230-volt d.c. power to cranes and mill auxiliaries; three transformer banks.

European Practice. Rolling Mill Practices—Germany, Spain, Russia, F. L. Estep. Iron and Steel Engr., vol. 6, no. 3, Mar. 1929, pp. 122–127. See also Iron Age, vol. 123, nos. 14 and 15, Apr. 4 and 11, 1929. Equipment in South Russian rolling mills is today very antiquated; sticking speed on Russian rod mills which is abnormally high; speed of rolls in which they are making Russian roof iron; practice at Thyssen Hutte plant, Hamborn, Germany; method of converting ingot into finished metal tie compared with English practice; mills in Spain described.

S

SAND, FOUNDRY

Control. Some Experiences in Sand Control, E. F. Wilson. Am. Foundrymen's Assn.—Preprint, for mtg. Apr. 8 to 11, 1929, pp. 183–198. Series of studies made in course of installation and development of sand laboratory for Jefferson Union Co., Lockport, N. Y., manufacturers of malleable iron fittings; inadequacy of vibrating test; cold and hot permeability blow-hole formation; sand holes; tests of new sands; routine sand tests; new sand addition; moisture content; clay content; sea coal; dry strength; feel of sand; gating; removal of fins.

SCREWS, CAP

Manufacture. Making Socket-Head Capscrews on a Production Basis, M. H. Flynn. Am. Mach., vol. 70, no. 8, Feb. 21, 1929, pp. 304–305, 7 figs. Machining operations and heat treating involved in manufacture of socket-head capscrews are described.

SHAFTS

Machine, Magnetic Testing of. Magnetic Probe of Machine Shafts (Sur le sondage magnétique des arbres de machines), J. Peltier. Académie des Sciences—Comptes Rendus (Paris), vol. 188, no. 10, Mar. 4, 1929, pp. 701–703, 1 fig. Instrument for testing machine shafts for probable inside defects and based upon variations of magnetic permeability in non-homogeneous field, is described.

STEAM

Heat Transmission in Condensation. Heat Transmission in Condensation of Superheated and of Saturated Steam (Der Waermeuebergang beim Kondensieren von Heiss- und Sattdampf), M. Jakob and S. Erk. Forschungsarbeiten auf dem Gebiete des Ingenieurwesens (Berlin), no. 310, pp. 1–8, 14 figs. partly on supp. plate. Report from German Government Institute of Engineering Physics, describing apparatus used and giving results of tests; application of Nusselt theory of water films; efficiency of heat transmission as function of velocity of steam flow.

Properties. Heat of Vaporization of Water and the Specific Volume of Saturated Steam for Temperatures up to 210 Degrees Centigrade (Die Verdampfungswaerme des Wassers und das spezifische Volumen von Sattdampf fuer Temperaturen bis 210 deg. cent.), M. Jakob. Forschungsarbeiten auf dem Gebiete des Ingenieurwesens (Berlin), no. 310, pp. 9–19, 9 figs. Report from German Government Institute of Engineering Physics giving details of apparatus and methods, also results of experimental study; review of previous research on problem.

STEAM CONDENSERS

Efficiency. The Efficiency of a Condenser. Engineer (Lond.), vol. 147, no. 3817, Mar. 8, 1929, pp. 269–270. Explanation of what is meant by efficiency in reference to condensers.

Regenerative. Regenerative Surface Condensers, T. Petty. Engineer (Lond.), vol. 147, nos. 3816 and 3817, Mar. 1, and 8, 1929, pp. 229–231 and 259–261, 8 figs. Basis of theory of condenser operation; mass condensation of steam; air concentration; reduction of condensate to equilibrium temperature; hydrodynamical resistance and regenerative velocity effects; partition of surface dimensions arising from presence of air.

Selection. Buying a Condenser, C. S. Lumley. Power, vol. 69, no. 13, Mar. 26, 1929, pp. 512–513. Basis of capitalization employed by consulting engineers in selecting fourth unit for Morrel Street Station, Detroit; condenser selected of straight down-flow type of horizontal two-pass design with 26,000 sq. ft. of surface made up of 4875 tubes, 20 ft. long and 1 in. in diameter; circulating water is supplied by two 12,750-g.p.m. pumps, each driven by open squirrel-cage motor designed for full voltage starting; tabulation of bids for condenser unit.

STEAM-ELECTRIC POWER PLANTS

Fuel Economy. 12-Lb. Pressure as a Dollar Saver, E. Jowett. Elec. World, vol. 93, no. 10, Mar. 9, 1929, p. 492. Annual saving of $144,700 is made in Northeast Station of Kansas City Power and Light Co., by bringing additional equipment from 300 lb. pressure at 700 deg. to 1200-lb. and 725 deg.; for annual output of 530,201,400 kw-hr. and with fuel at 67,000 B.t.u. for one cent, large fuel saving was effected.

High-Pressure. Experiences with High Pressures, R. Brown. Power, vol. 69, no. 14, Apr. 2, 1929, pp. 563–565 and (discussion) 565–566. Review of experiences at Edgar Station of Edison Electric Illuminating Co. of Boston; ruptures in superheater; bringing cold boiler into service has been frequent cause of leaks; new 1200-lb. turbine experiences; 1400-lb. boiler feed-pump experiences; shaft packing. Abstract of paper read before Am. Soc. Mech. Engrs.

Present Status of High-Pressure Steam Engineering (Stand der Hockdruckdampf-Technik) A. Heller. V.D.I. Zeit. (Berlin), vol. 73, no. 10 Mar. 9, 1929, pp. 345–346. Report on session of research committee of German Electric Works Assn.; abstracts of paper on high-pressure steam power plant (274 high-pressure boilers built or ordered in Germany since 1922), Mannheim 100-atmos. plant, Loeffler boilers, Renate mine 120-atmos. plant, construction material for high-pressure steam turbines, etc.

1200-Lb. Steam for Holland. Elec. World, vol. 93, no. 9, Mar. 2, 1929, pp. 429–433, 6 figs. New generating station of General Gas and Electric Corp., Holland, N. J., is designed for variable loads; economical operation to be secured with low first cost; furnaces having opposed firing are described.

Long Beach, Calif. New Large Electric

Power Generating Plants in California, R. Wilcox. Universal Engr., vol. 49, no. 3, Mar. 1929, pp. 17–22, 8 figs. Southern California Edison Co. places in operation new generators aggregating capacity of 170,000 kw.; two hydro units of 40,000 kw. each and one 90,000 kw. steam turbine unit; steam and electric equipment of Long Beach steam plants; condensing water pumps at low level; automatic boiler control; special attention to piping design; building and boilers designed to resist earthquakes.

Munich, Germany. Reserve Steam Power Plant of the Munich Municipal Central Station (Das Reserve-Dampfkraftwerk an der Isartalstrasse der Staedtischen Elektrizitaetswerke Muenchen), I. Bodler. Zeit. des Bayerischen Revisions-Vereins (Munich), vol. 33, nos. 2, 3 and 4, Jan. 31, Feb. 15 and 28, 1929, pp. 11–18, 31–36 and 49–55, 56 figs. Among factors governing design was low cost of installation and upkeep; results of comparative calculations of plants of high and low initial costs; low construction costs were achieved by use of high-duty boilers (only 7 boilers for 60,000 kw.); economy in space was effected by ingenious layout; detained costs are given, and particulars of buildings and equipment, performance, etc.

Oakland, Calif. New Units in the Oakland Plant of the Pacific Gas & Electric Co., C. W. Geiger. Nat. Engr., vol. 33, no. 2, Feb. 1929, pp. 99–101, 2 figs. Turbo-generator has rating capacity of 37,500 kw. and will carry load of 24,000 kw.; boilers operate at pressure at 450 lb. per sq. in. and superheaters raise temperature of steam to 730 deg. fahr.; condenser is horizontal tubular type.

Pulverized - Coal - Fired. Trenton Channel Station Eliminates Powdered Coal Dust from Cyclone Vents, H. E. Macomber. Power, vol. 69, no. 12, Mar. 19, 1929, pp. 464–467, 4 figs. Cotton bag filter systems with automatic shakers and collectors on 24 cyclones, eliminate dust nuisance at Detroit station; to avoid wetting filtering material, filter compartments, hoppers, and ducts are heat-insulated and preheated air is added to vent mixture before it enters filter to keep temperature above dewpoint; details of construction and operation and experience with fire hazards.

STEAM ENGINES

Meier Mattern Valve Gear. The Meier Mattern Hydraulic Valve Gear and Its Application to Marine Steam Engines, H. M. M. Mattern. Mar. Engr. and Motorship Bldr. (Lond.), vol. 52, no. 618, Mar. 1929, pp. 95–99, 9 figs. Description of valve gear fitted to two vessels, namely Borneo and Moena, to number of stationary engines, and to two locomotives belonging to Dutch railways; manner in which this gear operates; performance figures.

Reciprocating, Heat Transmission in. The Transfer of Heat in Reciprocating Engines, A. Nagel. Engineering (Lond.), vol. 127, no. 3294, Mar. 1, 1929, pp. 279–282, 16 figs. Consideration given to original problem of heat transfer in steam engine; description given of tests made in heat engines laboratory at Dresden from 1911 onward.

STEAM PIPE LINES

Connections. Safety of Steam Pipe Connections (De la securité des assemblages de tuyauteries à vapeur), V. Kammerer. Assns. Francaises de Propriétaires d'Appareils à Vapeur —Bul. (Paris), vol. 9, no. 34, Oct. 1928, pp. 249–289, 41 figs. Cases of breakdown of expanded pipe flanges cited; causes traced and remedies suggested.

Expansion Loops. Expansion Loops of Fittings and Straight Pipe, J. A. Freiday and F. A. Ericson. Power, vol. 69, no. 13, Mar. 26, 1929, pp. 514–515, 5 figs. Piping troubles due to distortion of pipe bends may be remedied by making expansion loops out of fittings; cross-section of pipe should not be distorted during fabrication; there should be no tendency to straighten out after installation; maximum amount of deflection in minimum space should be provided.

STEAM TURBINES

Back-Pressure. Steam-Turbine Regulations With Regard to an Economical Partload Operation, Especially in the Case of Back-Pressure Turbines (Beitrag zur Frage der Dampfturbinenregelung im Sinne eines wirtschaftlichen Teillastbetriebes, insbesondere bei Gegendruckturbinen), K. Jaroschek. Waerme (Berlin), vol. 52, nos. 8 and 9, Feb. 23 and Mar. 2, 1929, pp. 157–163 and 182–187, 25 figs. Three methods of overcoming loss of efficiency in change-over from full load to part load are discussed and compared; back-pressure turbines and back-pressure engines in part-load operation are compared.

Blade Failures. Many Factors Cause Turbine Blade Failures, W. E. Warner. Power Plant Eng., vol. 33, no. 7, Apr. 1, 1929, p. 408. Blading failures in turbines are caused by insufficient clearance or shaft slightly bent during manufacture, vibration and surface imperfections; temperature changes should be gradual; reheating sometimes employed to dry steam in last stages.

Design. Progress in the Design of Steam Turbines (Neuerungen im Dampfturbinenbau), P. Kaehler. Ingenieur (Hague), vol. 44, no. 7, Feb. 16, 1929, pp. E.23–E.28, 11 figs. Various turbines, multiple-stage, high and back-pressure and condensation types from 800 to 20,000 kw., turbines, multiple-stage, high- and back-pressure and condensation types from 800 to 20,000 kw., 3000 r.p.m. of Bergman Works, Berlin, are described. Read before Roy. Instn. Engrs. of Holland. (In German.)

The Modern Steam Turbine. Engineering (Lond.), vol. 127, no. 3292, Feb. 15, 1929, pp. 203–204. Development of steam turbine is discussed; improvement in thermal efficiencies due to rise in pressures and temperatures, and to introduction of progressive feed heating; practicability of high temperatures; growth in output of machines designed to run at 3000 r.p.m.; reference is made to paper by H. L. Guy presented before Inst. Mech. Engrs., previously indexed from same journal Feb. 1 and 8, 1929.

Rubber-Mill Plant. High Pressure Turbine Furnishes Cheap Power in Ajax Rubber Plant, K. W. Karlson. Power, vol. 69, no. 13, Mar. 26, 1929, pp. 502–505, 3 figs. Remodeled plant of Ajax Rubber Co., of Racine, Wis., using new 425-lb. boiler and 1500-kw. turbine bleeding at 170 lb. to station header and exhausting at 85 lb. to process, makes possible power cost per kw-hr. ranging from 0.663 cts. at one-third capacity to 0.358 cts. at full load; control system provides adjustable constant flow to turbine throttle; process steam under back-pressure control.

STEEL

Alloy. See ALLOY STEEL.

Chromium-Nickel. See CHROMIUM-NICKEL STEEL.

Hardness Testing. Relation between Various Degrees of Hardness of Unhardened Carbon Steel (Die Beziehung zwischen verschiedenen Haerteziffern bei ungehaerteten Kohlenstoffstaehlen), A. Wallichs and H. Schallbroch. Maschinenbau (Berlin), vol. 8, no. 3, Feb. 7, 1929, pp. 69–74, 10 figs. Steel containing from 0.1 to 1.0 per cent of carbon was exposed to various hardening tests, as result of which curve is plotted showing ratio of Brinell hardness to new hardness coefficient and corresponding equations are derived. Bibliography.

High-Strength. High-Strength Structural Steels, E. E. Thum. Iron Age, vol. 123, no. 12, Mar. 21, 1929, pp. 797–800, 1 fig. Low-manganese steel, in as-rolled condition, posseses high proportional limit and impact strength, and is used for boilers, bridges, structures and ships; manganese in rail steels; high-elastic-limit steel for ships; German "F" or Freund steel; high-strength boiler plate; compressed gas cylinders; strong structural steels.

STOKERS

Modern Development of. Modern Stoker Development, C. F. Hirshfeld and G. U. Moran. Power, vol. 69, no. 12, Mar. 19, 1929, pp. 490–491, 6 figs. Review of stoker development indicates that dimensions have increased more than intensity of use; present trends with stokers seem to be toward relatively smaller furnaces and operation of boilers at successively higher ratings; proper distribution of coal to stoker; automatic control. Abstract of paper read before Mid-West Power Eng. Conference.

STROBOSCOPES

Tuning Forks. An Electrically Maintained Tuning Fork With a Calibrated Speed Adjustment, D. C. Gall. Jl. of Sci. Instruments (Lond.), vol. 6, no. 2, Jan. 1929, pp. 18–19, 1 fig. Description of special type of adjustment fitted to 50-cycle fork made by H. Tinsley and Co., for use in stroboscopic measurements and for controlling phonic motors for operating constant-speed devices.

T

TEXTILE MACHINERY

Cotton Spinning. Drawing Rollers in Cotton Spinning (Das Walzenstreckwerk in der Baumwollspinnerei), E. Toennigessen. V.D.I. Zeit. (Berlin), vol. 73, no. 9, Mar. 2, 1929, pp. 298–301, 10 figs. Johannsen's theory of high draft and consequent improvement in design of equipment are discussed.

Electric Drive. Speed Control of Ring-spinners (Ueber die Geschwindigkeitsregelung bei den Ringspinnmaschinen), F. Oertel. V.D.I. Zeit. (Berlin), vol. 73, no. 9, Mar. 2, 1929, pp. 313–318, 11 figs. Speed and load relations between machine and motor are emphasized and conclusions drawn are used in devising speed control of individual drives.

Noise Elimination. Prevention of Noises in Weaving Mills (Germaeuschverhuetung in Webereien), Denker. V.D.I. Zeit. (Berlin), vol. 73, no. 9, Mar. 2, 1929, p. 278. Noise mainly caused by shuttles; cabler machine without shuttles described; other noise sources; ball-bearings, nonmetallic gearing; mill-structure; noise absorption.

TOLERANCES

Skoda vs. D.I.N. System. German and Skoda Tolerances Compared—Discussion, N. N. Sawin. Am. Mach., vol. 70, no. 10, Mar. 7, 1929, pp. 397–400. Investigation recently reported by Schlesinger contains evidence that German system sacrifices certain practical advantages for theoretical orderliness; changes in certain tight fits, and closer tolerances for small diameters are necessary; close tolerances on large diameters are meaningless; changes in medium force, wringing, and tight fits.

TOOLS

Small, Control of. Centralized Records for Efficient Tool Control, N. J. Browne and N. Holve. Am. Mach., vol. 70, nos. 12 and 13, Mar. 21 and 28, 1929, pp. 467–469 and 511–514, 11 figs. Mar. 21: Further details of system employed by De Laval Separator Co., and some of forms used in keeping records of master tools, tool manufacturing orders, tool list, routing, tool depreciation, and balance card. Mar. 28: Description of method of issuing order is completed; more forms and sequence of filling out.

Thread-Cutting. Correcting Round Nosed Tools, Especially Chasers (Profilkorrekturen an Rundstaehlen, insbesondere an Gewindestrehlern fuer Spitzengewinde), T. Eggert. Maschinenbau (Berlin), vol. 8, no. 4, Feb. 1, 1929, pp. 116–119, 5 figs. Shaping and correcting cutting points of round-nosed tools, in order to obtain interchangeable screw threads.

Tool Holders. Holding Devices and Their Application (Spannelemente und ihre Anwendung in der Fabrikation), H. Reimers. Werkstattstechnik (Berlin), vol. 23, no. 3, Feb. 1, 1929, pp. 69–73, 53 figs. Rules for design are given and application exemplified.

W

WAGES

Payment Plans. The Advantages of Running Machine-Hour Measurements. Nat. Assn. Cost Accountants—Bul., vol. 10, no. 14, Section 1, Mar. 15, 1929, pp. 913–923. Advantages to be gained from paying machine operatives on basis of hours of running time of machine rather than on basis of production are stabilization of wages, reduction in direct labor costs, speeding up of production, registration of efficiency, simplification of rate fixing, payroll work, and production control.

WELDING

Aluminum. See ALUMINUM, Welding; ALUMINUM ALLOYS, Welding.

Bronze Welding Rods. Recent Developments in Brass Rods, A. R. Lytle. Acetylene Jl., vol. 30, no. 9, Mar. 1929, pp. 376–378 and 386, 9 figs. Description of new brass welding rods and their applications to welding copper alloys and to general bronze welding. Paper read before Int. Acetylene Assn.

WOODWORKING PLANTS

Cost Accounting. Woodworking Costs, J. J. Berliner. Indus. Woodworking, vol. 29, no. 6, Mar. 1929, pp. 14–16, 19–21, 3 figs. System of obtaining complete factory costs explained; how costs are summarized and applied to each job.

Sash and Door Production. Door and Window Frame Production Methods, A. T. Ray. Wood-Worker, vol. 48, no. 1, Mar. 1929, pp. 35–36, 1 fig. Ideas for cutting milling costs by installation of special machines; cutting large lots of standard stock at one time; special layouts of mullion, triple, and quadruple frames on rods which accompany work through plant.

WROUGHT IRON

Manufacture. New Process for Making Wrought Iron. Fuels and Furnaces, vol. 7, no. 3, Mar. 1928, pp. 449–450, 3 figs. Puddle ball (weight approx. 2000 lb.) produced in 20 min. by mechanical process of making wrought iron.

IN TWO SECTIONS—SECTION TWO

MECHANICAL ENGINEERING

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What It's All About

DIVERSITY of subject-matter, far from indicating a lack of emphasis on professional specialties, draws attention to the breadth of the field of mechanical engineering, and serves to impress specialists with the broader possibilities of their interests and influence. In MECHANICAL ENGINEERING for June will be found papers on ore handling, airports, naval construction, education, research, corrosion, steam condensers, history, and biography, besides the usual departments devoted to the perennial interest in standardization, engineering progress, index to literature, etc.

Persons outside of the profession are usually amazed at the breadth of interest of subjects treated in MECHANICAL ENGINEERING, and at their ability to understand much that it contains. This is because mechanical engineering is the engineering of the industries; and inasmuch as we live in an industrial era the average person has industrial interests and contacts. After you have read the résumé of this month's MECHANICAL ENGINEERING, pass it on to some one who does not regularly see the journal so that he may know "what it's all about!"

Ore Handling

WHEN the A.S.M.E. holds a meeting in a locality like Salt Lake City, those who attend have an opportunity of studying at first hand a branch of industry such as the handling of copper ore. Through his paper on "Ore Handling at the Utah Copper Company's Mine and Mills," which appears in the June issue of MECHANICAL ENGINEERING, the author, H. C. Goodrich, who is chief engineer of the Utah Copper Company, brings this opportunity within the reach of those not fortunate enough to be able to visit the mine in person. The paper is to be presented at the Semi-Annual Meeting of the A.S.M.E., Salt Lake City, Utah, July 1 to 4.

Next Month—and Later

WAGE INCENTIVES FOR DIRECT LABOR, by Charles W. Lytle.

THE FUEL AND SMOKE PROBLEM IN SALT LAKE CITY, by Geo. A. Orrok and W. H. Trask, Jr.

MODERN PRACTICE IN THE QUARRYING AND MILLING OF MARBLE, by J. P. McCluskey.

RECENT DEVELOPMENTS IN BOILER-METAL EMBRITTLEMENT, by H. F. Rech.

STEAM-GENERATING APPARATUS IN FOREST AREAS AS RELATED TO CAUSES OF FOREST FIRES, by A. C. Coonradt.

SMOKELESS COMBUSTION IN DOMESTIC HEATING PLANTS, by Victor J. Azbe.

Airport Design and Construction

PHILIP R. LOVE, who is well known in this country as Colonel Lindbergh's friend and as a former air-mail pilot, writes in the June MECHANICAL ENGINEERING on "Fundamentals and Certain Details of Airport Design and Construction." His paper was one of forty presented at the Third National Meeting of the A.S.M.E. Aeronautic Division, held in St. Louis, May 27 to 30.

The problem discussed by Mr. Love is engaging the attention of hundreds of cities throughout the country, and the reasoned judgment of engineers is essential in the solution of the problem wherever it presents itself. Mr. Love puts his readers in a proper state of humility of mind by his first sentence, which is as follows: "Probably no other phase of aeronautical development offers as fertile a field for the exercise of enthusiastic ignorance as does the selection and preparation of airports." It is for the engineer to counteract enthusiastic ignorance by a study of all the facts. When you talk with your air-minded neighbors, Mr. Love's paper will help the arguments on your side of the question.

Who Knows Hoover?

IN A COPY of the program of the ceremonies at the White House when Herbert Hoover was presented the John Fritz Medal for his attainments as "Engineer, scholar, organizer of relief to war-stricken peoples, public servant," appeared an account of the life of the President which is so well prepared that all engineers will be glad to read it. In the June issue of MECHANICAL ENGINEERING this monograph is reprinted. Many who know some of the important features of the man's life will find this brief and sympathetic statement of absorbing interest.

Industrial Research

ENGINEERING makes professional contact with Science once a year at least when the American Association for the Advancement of Science holds its annual meeting and Section M (Engineering) has its part on the program. At the meeting last December a session was devoted to the organization of scientific research in industry. Two of the papers read at this session are published in MECHANICAL ENGINEERING for June.

F. B. Jewett, vice-president of the American Telephone and Telegraph Company and president of the Bell Telephone Laboratories, writes on "Finding and Encouragement of Competent Men." The problem, he says, is in no substantial measure different in industrial research from what it is in any walk of life. His own experiences have led him to rely largely upon "the considered judgment of a baker's dozen or so of men in the academic world." Dr. Jewett emphasizes recognition of achievement as essential to encouragement.